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# THE U.S. FOOD AND FIBER SECTOR: ENERGY USE AND OUTLOOK

A Study of the Energy Needs of the Food Industry

PREPARED BY

THE ECONOMIC RESEARCH SERVICE,
U.S. DEPARTMENT OF AGRICULTURE

FOR THE

SUBCOMMITTEE ON AGRICULTURAL CREDIT AND RURAL ELECTRIFICATION

OF THE

COMMITTEE ON AGRICULTURE AND FORESTRY
UNITED STATES SENATE



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# LETTER OF TRANSMITTAL

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
*Washington, D.C., August 19, 1974.*

Hon. GEORGE S. McGOVERN,
*Chairman, Subcommittee on Agricultural Credit and Rural Electrification, U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: I am pleased to transmit to you the Economic Research Service report, "The U.S. Food and Fiber Sector: Energy Use and Outlook," requested by the Senate Subcommittee on Agricultural Credit and Rural Electrification.

The ERS study focuses on current fuel use in farm input supply, farm production and family living, processing, marketing, and distribution of farm products to consumers. It traces shifts and trends in practices and fuel use in the various subsectors and projects demand for energy to 1980.

The report addresses the possible impact of rising fuel prices on farm production and retail food prices. It examines the Federal Energy Administration's petroleum fuel allocation program as it relates to agriculture. The report also identifies a number of energy related problems that impinge on the performance of our food and fiber system.

Sincerely,

DON PAARLBERG,
*Director, Agricultural Economics.*

Enclosure.

## FOREWORD

In April of this year, on behalf of the Subcommittee on Agricultural Credit and Rural Electrification, I requested the Economic Research Service of the U.S. Department of Agriculture to undertake a study of the energy and fuel outlook for the U.S. food and fiber sector of our economy. The report that follows is in response to that request.

This study, entitled, "The U.S. Food and Fiber Sector: Energy Use and Outlook" not only reveals what a highly complex interrelated system the U.S. food and fiber sector is, but also reveals that this particular sector of our economy requires about 13 percent of our Nation's total energy consumption.

The study examines the energy use of the food and fiber sector by various subsectors—input supply, farm production and family living, food processing, and marketing and distribution—and the impact of rising fuel costs on food prices.

The report identifies 4,667 trillion Btu of energy used in 1970 of which farm production took 22 percent; family living, 12 percent; food processing, 28 percent; marketing and distribution, 18 percent; and selected input industries, 20 percent. Not included in the report are energy requirements of the commercial food fishing industry; commercial forestry; and processing, marketing and retailing of fiber products. Thus, the report is mainly oriented toward the food side of the food and fiber sector and does not include all energy needs of the entire sector.

Currently, farm production requires about 8 billion gallons of petroleum fuel, about 3 percent of the U.S. total. There have been significant shifts in the composition of petroleum fuels used on farms, as diesel engines have replaced gasoline units in tractors, and, more recently, combines. It is estimated that by 1980, over 80 percent of agricultural tractors and 90 percent of self-propelled combines sold new will be diesel-powered. Fuel usage by major farm machines in 1980 is estimated to be 6.1 billion gallons, of which 38 percent will be diesel fuel.

LP gas use in farm engines is declining. However, this fuel is gaining importance in crop drying, tobacco curing, and poultry brooding. Increased field shelling of corn in recent years has stimulated demand for LP gas and offset reduced demand in motors. By 1980, LP gas use will be up about 8 percent over the 1970 level.

About one-third of the energy used on farms is for family living purposes. Fuel oil and LP gas is used extensively for home heating. LP gas and electricity are major cooking fuels. While farm numbers are expected to decline 21 percent by 1980, energy use for family living is expected to decline only about half that much.

The 14 food processing industries selected for this study accounted for 53 percent of the purchased fuels (including electricity) used for heat and power in all U.S. food and kindred products processing in-

dustries; 40 percent of the value added by manufacturing; and 42 percent of the employment in 1971. Industries included are: meat packing and sausage preparation; dairy products; canning and freezing fruits and vegetables; frozen specialties; sugar refining; wet corn milling; and malt beverages.

Natural gas was the major energy source for processing in 1971 by electricity. Btu needs for these industries are expected to increase 19 percent between 1971 (758 trillion) and 1980 (901 trillion). The largest increase in heat and power needs is for frozen specialties—(pizzas, TV dinners, snacks)—doubling by 1980 to 55 trillion Btu.

As agricultural marketings are expected to continue expanding to meet the needs of our growing population and export demands, 1980 energy requirements for transporting food and fiber products will be 19 percent above the 1970 level of 3.8 billion gallons of gasoline and diesel fuel. Gasoline use in farm trucks will increase 14 percent, while diesel use in commercial trucks, rail, and water transportation will rise 20 percent.

The report examines energy needs for five major input industries: feed fertilizer, pesticides, machinery, and petroleum. Natural gas is the major fuel used providing 83 percent of the Btu in 1970. By 1980, these industries will need at least 15 percent more Btu to supply the inputs needed in the sector.

The timely supply of fossil fuels to the food and fiber sector is imperative for orderly processing and marketing of farm production inputs and food products at least cost prices. Curtailment of natural gas and disruption of petroleum fuel supplies will require substantial capital expenditure for standby heat and power equipment and, where used as a feedstock, shortages of these fuels will reduce supplies of inputs and thus food and fiber. For firms that recently converted their plants to use natural gas to satisfy environmental constraints, the cost of reconverting may be so high as to force some of them out of business. For firms to shift to using coal the process is not simple. The hardware to convert is not available and will require considerable lead time for design, manufacture, and installation.

On behalf of both the Subcommittee and the full Committee on Agriculture and Forestry, I want to thank Dr. Don Paarlberg and the Economic Research Service of the U.S. Department of Agriculture for their cooperation in conducting this timely and important study.

George S. McGovern,
*Chairman, Subcommittee on Agricultural Credit and Rural Electrification.*

# PREFACE

The food and fiber sector encompasses a broad and diverse group of commodities and industries. It includes food production on farms and from commercial fishing; fiber production on farms—basically cotton, wool and farm forest products; and fiber production from commercial forests. It also includes the many input supply, processing, marketing and distribution firms that prepare the raw products and present them to consumers at the time, place, and in the form desired.

This report presents energy requirements for farm production including food, cotton, wool and farm forest products. Time did not permit an investigation of the entire sector. Excluded are energy requirements of the commercial food fishing industry and commercial forestry. Further, this report does not include the processing, marketing and retailing requirements of the fiber products. Fish as a food product, however, is included in the retailing section.

The report is mainly oriented toward the food side of the food and fiber sector, and significantly understates the energy needs of the sector. Finding are based primarily on available secondary data. Time did not permit generating new information to fill the countless energy data gaps throughout the complex system. In attempting to outline the functions and fuel use of the various subsectors in the system we have been forced in some instances to generalize for lack of supporting data.

## SUMMARY

The U.S. food and fiber sector is a highly complex, interrelated system that requires about 13 percent of our total energy. While other countries have large proportions of the populace engaged in producing and distributing food, only one worker in five in this country is so employed. Instead of human and animal energy we rely on energy from fossil fuel to produce our food and fiber.

From 1940 to 1973 the food and fiber sector had nearly doubled farm output. Not only do we feed ourselves, but we also feed millions abroad. The output from 96 million acres—30 percent of our harvested acreage is exported. In producing this expanding output our food and fiber system has had increasing energy needs—about a 4 percent annual growth rate. This is the same rate at which the entire Nation has increased consumption of energy.

This study examined the energy needs of several industries in the food and fiber sector and projects their energy needs to 1980. It examined the chief input supply industries, the farm production and family living subsector, several food processing industries, and the marketing and distribution subsector.

For 1970, that portion of the food and fiber sector discussed in this report used 4,667 trillion Btu of fossil fuel energy. Other studies have indicated our total food system uses from 6,100 to 8,618 trillion Btu.

Determining the precise level of energy use for each industry in the sector is presently impossible because energy statistics are not available for all industries.

Of the 4,667 trillion Btu used in 1970, farm production took 22 percent; farm family living, 12 percent; food processing, 28 percent; marketing and distribution, 18 percent; and the selected input industries, 20 percent (summary table 1).

By 1980 energy demanded by these selected food and fiber industries is projected to rise 11.3 percent to 5,196 trillion Btu. This assumes essentially the same quantity of energy per unit of output in 1980 as in 1970. However, as energy costs rise, conservation through management and better technology may reduce energy inputs per unit of output.

Energy demand in the various subsectors will change from 1970 to 1980. While the total food and fiber products are expected to be 8 to 10 percent greater in 1980, energy needs differ by subsector.

*Farm production.*—Production of farm products in 1980 will rise above the 1973 level to satisfy growing domestic and export needs. Fuel use will rise a modest 4 percent to 1,095 trillion Btu. This greater production will be from 354 to 365 million acres; substantially lower than the 371 million acres harvested in 1973. Yields will rise as farmers continue to adopt new technology. The shift from gasoline to diesel powered tractors and combines will continue and over 40

percent of all farm production fuel will be diesel (summary table 2). LP gas use will increase slightly as farmers expand crop drying activities.

*Family living.*—Energy used for farm family living is expected to drop 10 percent as the number of farm families decline 21 percent to 2.33 million in 1980. Both natural gas and LP gas use will increase as farm homes shift to these fuels for space heating.

*Food processing.*—Energy demands will increase from 28 to 30 percent of the total as more foods are processed to higher levels of convenience. The greatest increase is in frozen specialities—TV dinners, pizzas, and other snack foods—doubling Btu needs by 1980. Food processing will consume as many Btu as farm production and family living combined.

Natural gas is the major energy source for processing food and fiber about half of the total. Demand for this fuel is projected to increase over 115 trillion Btu by 1980.

*Marketing and distribution.*—Transporting and marketing food and fiber will require 19 percent more Btu of energy in 1980 than in 1970. This is in line with the expanded outputs anticipated. The demand for diesel fuel by trucks, trains, and barges for transporting products from farms to the city of final destination will account for about 90 percent of the Btu identified.

*Input manufacturing.*—Expanded data show the input industries will use the same percentage of the sector's energy in 1980 as in 1970—20 percent. The fertilizer industry is the heaviest energy consumer of those industries studied—accounting for nearly 60 percent of the Btu.

Natural gas predominated as the energy source, providing 83 percent of the Btu.

*Fuel used.*—Of the 4,667 trillion Btu energy used in 1970 for that portion of the food and fiber sector discussed in this report, 50 percent was liquid petroleum fuel—primarily diesel fuel, gasoline and LP gas. Natural gas supplied 30 percent of the Btu and electricity, 14 percent. By 1980, assuming the same fuel sources for industries, liquid petroleum fuels would decline to 48 percent of the Btu while natural gas increases from 30 to 32 percent and electricity rises slightly.

The predicted short supply of natural gas portends serious energy supply problems for the food and fiber sector. Natural gas is the feedstock for our nitrogen fertilizer production and is the main heat and power fuel for many of the input supply and food processing firms. Conversion of these plants to utilize coal or oil, in the absence of natural gas, would be costly and would increase retail food prices.

SUMMARY TABLE 1.—BTU USED IN U.S. FOOD AND FIBER SECTOR BY MAJOR TYPES OF INDUSTRIES AND ENERGIES, IN 1970 OR LATER AND 1980

| Item | 1970 [1] | | 1980 | | Change in percent |
|---|---|---|---|---|---|
| | Trillion Btu | Percent | Trillion Btu | Percent | |
| Type of industry or use: | | | | | |
| Farm production | 1,051.4 | 22.5 | 1,095.3 | 21.1 | +4.2 |
| Farm family living | 554.6 | 11.9 | 499.2 | 9.6 | −10.0 |
| Food and kindred product processing | 1,302.9 | 27.9 | 1,548.3 | 39.8 | +19.8 |
| Marketing and distribution | 832.7 | 17.9 | 988.9 | 19.0 | +18.8 |
| Input manufacturing [2] | 925.3 | 19.8 | 1,063.8 | 20.5 | +15.0 |
| Total | 4,666.9 | 100.0 | 5,195.5 | 100.0 | +11.3 |
| Type of energy: | | | | | |
| Liquid fuels and LP gas | 2,334.5 | 50.0 | 2.502.3 | 48.2 | +7.2 |
| Residual fuel oil | 97.5 | 2.1 | 115.0 | 2.2 | +17.9 |
| Natural gas | 1,414.4 | 30.3 | 1,652.7 | 31.8 | +16.8 |
| Electricity | 643.0 | 13.8 | 73.86 | 14.2 | +14.9 |
| Coal and coke | 165.8 | 3.6 | 173.6 | 3.3 | +4.7 |
| Other | 11.6 | 0.2 | 13.3 | 0.3 | +14.7 |
| Total | 4,666.9 | 100.0 | 5,195.5 | 100.0 | +11.3 |

[1] For some industries data are for 1971, 1972 or 1973.
[2] Includes estimates for 6 selected industries.

SUMMARY TABLE 2.—SUMMARY OF BTU USED IN U.S. FOOD AND FIBER SECTOR, BY FUNCTIONS, IN 1970 AND 1980

[Billion Btu]

| Function | Gasoline | | Diesel | | Distillate Fuel Oil | | LP Gas | |
|---|---|---|---|---|---|---|---|---|
| | 1970[1] | 1980 | 1970[1] | 1980 | 1970[1] | 1980 | 1970[1] | 1980 |
| Farm Production: | | | | | | | | |
| Crops | 377, 372 | 375, 215 | 280, 451 | 300, 668 | | | 93, 113 | 100, 275 |
| Livestock | 125, 791 | 125, 071 | 93, 483 | 100, 222 | | | 31, 037 | 33, 425 |
| Total | 503, 163 | 500, 286 | 373, 934 | 400, 890 | (5) | (5) | 124, 150 | 133, 700 |
| Family Living: | | | | | | | | |
| Transportation | 179, 603 | 179, 603 | 968 | 968 | | | | |
| Home uses | | | | | 118, 442 | 68, 374 | 104, 381 | 114, 504 |
| Total | 179, 603 | 179, 603 | 968 | 968 | 118, 442 | 68, 374 | 104, 381 | 114, 504 |
| Food and Kindred Products:[2] | | | | | | | | |
| Processing—14 selected industries: | | | | | | | | |
| Meat Packing | | | | | 3, 966 | | 2, 523 | |
| Sausage; other prepared meat | 23 | | | | 1, 848 | | 274 | |
| Dairy products[3] | 4, 838 | | | | 19, 594 | | 4, 354 | |
| Canned fruits and vegetables | | | | | 529 | | 1, 704 | |
| Frozen fruits and vegetables[4] | | | | | 242 | | 483 | |
| Wet corn milling | | | | | 3, 378 | | 225 | |
| Cane sugar refining | | | | | 142 | | | |
| Beet sugar refining | | | | | 75 | | | |
| Malt beverages | | | | | 3, 641 | | 412 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total, 14 selected industries | 4, 861 | 5, 403 | | | 33, 415 | 39, 624 | 9, 975 | 11, 707 |
| Total, 28 other industries | 2, 956 | 3, 887 | | | 23, 912 | 28, 501 | 6, 962 | 8, 421 |
| Total, 42 industries | 7, 817 | 9, 290 | | | 57, 327 | 68, 125 | 16, 937 | 20, 128 |
| Marketing and Distribution: | | | | | | | | |
| Transporting farm products to cities of final consumption | 47, 027 | 53, 781 | 470, 009 | 561, 108 | | | | |
| Transporting farm inputs from plants and warehouses to firms | 28, 766 | 32, 518 | 286, 845 | 341, 449 | | | | |
| Total | 75, 793 | 86, 299 | 756, 854 | 902, 557 | | | | |
| Input Manufacturing: [2] | | | | | | | | |
| Prepared feeds and ingredients | 1, 073 | 1, 183 | | | 3, 415 | 3, 765 | 2, 927 | 3, 227 |
| Animal and marine fats and oils | 238 | 299 | | | 2, 274 | 2, 861 | 272 | 341 |
| Fertilizer | | | | | 2, 286 | 3, 037 | | |
| Farm machinery | | | | | 1, 136 | 1, 200 | | |
| Pesticides | | | | | 309 | 324 | | |
| Petroleum | | | | | 1, 200 | 1, 268 | | |
| Total | 1, 311 | 1, 482 | | | 10, 620 | 12, 455 | 3, 199 | 3, 568 |
| Grand total | 767, 687 | 776, 960 | 1, 131, 756 | 1, 304, 415 | 186, 389 | 148, 954 | 248, 667 | 271, 900 |

Footnotes at end of table.

SUMMARY TABLE 2.—SUMMARY OF BTU USED IN U.S. FOOD AND FIBER SECTOR, BY FUNCTIONS, IN 1970 AND 1980—Continued

| Function | Residual Fuel Oil | | Natural gas | | Electricity | | Coal | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970 or later | 1980 | 1970 or later | 1980 | 1970 or later | 1980 | 1970 or later | 1980 | 1970 or later | 1980 | 1970 or later | 1980 |
| Farm Production: | | | | | | | | | | | | |
| Crops | | | | | 12, 539 | 15, 098 | | | | | 763, 475 | 791, 256 |
| Livestock | | | | | 37, 617 | 45, 294 | | | | | 287, 928 | 304, 012 |
| Total | | | | | 50, 156 | 60, 392 | | | | | 1, 051, 403 | 1, 095, 268 |
| Family Living: | | | | | | | | | | | | |
| Transportation | | | | | | | | | | | 180, 571 | 180, 571 |
| Home uses | | | 37, 260 | 44, 505 | 87, 006 | 81, 438 | 26, 936 | 9, 828 | | | 374, 025 | 318, 649 |
| Total | | | 37, 260 | 44, 505 | 87, 006 | 81, 438 | 26, 936 | 9, 828 | | | 554, 596 | 499, 220 |
| Food and Kindred Products: | | | | | | | | | | | | |
| Processing—14 selected industries: | | | | | | | | | | | | |
| Meat Packing | 6, 249 | | 58, 643 | | 36, 652 | | 12, 137 | | | | 120, 170 | 137, 923 |
| Sausage; other prepared meat | 844 | | 11, 045 | | 8, 581 | | 205 | | | | 22, 820 | 25, 864 |
| Dairy products | 9, 918 | | 84, 425 | | 110, 792 | | 7, 983 | | | | 241, 904 | 248, 041 |
| Canned fruits and vegetables | 3, 995 | | 40, 888 | | 9, 634 | | 1, 997 | | | | 58, 747 | 72, 880 |
| Frozen fruits and vegetables | 1, 353 | | 20, 341 | | 24, 157 | | 1, 739 | | | | 48, 315 | 83, 658 |
| Wet corn milling | 976 | | 33, 183 | | 10, 586 | | 26, 727 | | | | 75, 075 | 96, 061 |
| Cane sugar refining | 14, 341 | | 32, 718 | | 285 | | | | | | 47, 486 | 48, 624 |
| Beet sugar refining | 1, 790 | | 49, 458 | | 1, 044 | | 19, 246 | | 2, 984 | | 74, 597 | 89, 749 |
| Malt beverages | 7, 901 | | 26, 312 | | 25, 625 | | 4, 809 | | | | 68, 700 | 97, 750 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total, 14 selected industries | 47,367 | 56,735 | 357,013 | 424,159 | 227,356 | 270,165 | 74,843 | 89,155 | 2,984 | 3,602 | 757,814 | 900,550 |
| Total, 28 other | 34,715 | 40,808 | 256,644 | 305,087 | 163,509 | 194,323 | 54,142 | 64,126 | 2,228 | 2,591 | 545,068 | 647,744 |
| Total, 42 industries | 82,082 | 97,543 | 613,657 | 729,246 | 390,865 | 464,488 | 128,985 | 153,281 | 5,212 | 6,193 | 1,302,882 | 1,548,294 |
| Marketing and Distribution: | | | | | | | | | | | | |
| Transporting farm products to cities of final consumption | | | | | | | | | | | 517,036 | 614,889 |
| Transporting farm inputs from plants and warehouses to firms | | | | | | | | | | | 315,611 | 373,967 |
| Total | | | | | | | | | | | 832,647 | 988,856 |
| Input Manufacturing: | | | | | | | | | | | | |
| Prepared feeds and ingredients | 2,341 | 2,582 | 51,999 | 57,334 | 35,511 | 39,155 | 293 | 323 | | | 97,559 | 107,569 |
| Animal and marine fats and oils | 3,123 | 3,928 | 22,372 | 28,136 | 5,398 | 6,789 | 272 | 341 | | | 33,949 | 42,695 |
| Fertilizer | 930 | 1,215 | 491,044 | 581,477 | 58,743 | 70,086 | 1,150 | 1,518 | 1,554 | 2,025 | 555,707 | 659,358 |
| Farm machinery | 660 | 700 | 18,009 | 18,400 | 4,436 | 4,500 | 5,345 | 5,400 | 1,798 | 1,800 | 31,384 | 32,000 |
| Pesticides | 390 | 409 | 6,417 | 6,747 | 921 | 967 | 1,593 | 1,672 | 696 | 731 | 10,326 | 10,850 |
| Petroleum | 8,000 | 8,665 | 173,700 | 186,834 | 10,000 | 10,779 | 1,200 | 1,268 | 2,300 | 2,536 | 196,400 | 211,350 |
| Total | 15,444 | 17,499 | 763,541 | 878,928 | 115,009 | 132,276 | 9,853 | 10,522 | 6,348 | 7,092 | 925,325 | 1,063,822 |
| Grand total | 97,526 | 115,042 | 1,414,458 | 1,652,679 | 643,036 | 738,594 | 165,774 | 173,631 | 11,560 | 13,285 | 4,666,853 | 5,195,460 |

[1] Data vary by subsectors from 1970 to 1973.
[2] The distribution of total Btu for 1980 by fuel type was assumed to be the same as 1971. No distribution was made for individual industries.
[3] Includes 5 industries.
[4] Includes frozen specialties.
[5] Included with diesel fuel.

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# THE U.S. FOOD AND FIBER SECTOR: ENERGY USE AND OUTLOOK

## INTRODUCTION

American consumers can go to a nearby supermarket and obtain the widest possible choice of foods in fresh, canned, or frozen form at least six days a week, every week of the year. In no other country is there a food and fiber system to parallel ours.

This is a highly complex system involving approximately 17 million people, one U.S. worker in five. The input subsector which provides items such as fertilizer, pesticides, machinery, fuel, fencing, and many other inputs used in farm production employs about 2 million people. The farm production subsector has about 2.8 million farms and fewer than 3.3 million operators and family workers. Hired farm workers number just over a million. In food processing and storage, distribution and marketing, and in food preparation centers away from home some 10 million persons are employed. In total, some 7 percent of our population is employed in the U.S. food and fiber system in some manner.

This is a vastly different food and fiber system than is seen in developing countries where 50 to 80 percent of the population are farm people and perhaps another 10 percent are engaged in food and fiber distribution.

In place of this vast reliance on human energy to grow and distribute food we rely on energy from fossil fuel. It is needed at every step from manufacturing inputs and supplying them to the farm, processing of raw farm products, through storage, distribution and marketing phases, and on to final consumption. The American food and fiber system is energy intensive. No other nation in the world uses as much energy in its food system.

In 1970, an estimated 12–13 percent of all U.S. energy was consumed for food production, processing, preservation, and cooking. By major industry group, 24 percent of the total was used in input manufacturing and on farms, the processing industry accounted for 39 percent, and commercial firms and homes used 37 percent of the energy consumption in the food system (table 1). [50] [1]

[1] Numbers in brackets refer to references cited.

TABLE 1.—ENERGY USE IN THE U.S. FOOD SYSTEM, 1940-70, SELECTED YEARS

[$10^{12}$ Btu]

| | 1940 | 1947 | 1950 | 1954 | 1958 | 1960 | 1964 | 1968 | 1970 |
|---|---|---|---|---|---|---|---|---|---|
| On farm: | | | | | | | | | |
| Fuel | 277.8 | 539.6 | 626.9 | 685.7 | 710.3 | 746.0 | 848.8 | 896.8 | 920.6 |
| Electricity | 2.8 | 127.0 | 130.5 | 158.7 | 174.6 | 182.9 | 198.4 | 227.4 | 253.2 |
| Fertilizer | 49.2 | 77.4 | 95.2 | 121.4 | 127.8 | 162.7 | 238.1 | 345.2 | 373.0 |
| Agri. steel | 6.3 | 7.9 | 10.7 | 9.9 | 7.9 | 6.7 | 9.9 | 9.5 | 7.9 |
| Farm machinery | 35.7 | 137.7 | 119.0 | 117.1 | 199.2 | 206.3 | 238.1 | 297.6 | 317.4 |
| Tractors | 50.8 | 99.2 | 122.2 | 93.6 | 65.1 | 46.8 | 79.4 | 81.3 | 76.6 |
| Irrigation | 71.4 | 90.5 | 99.2 | 117.5 | 129.0 | 132.1 | 135.3 | 138.1 | 138.9 |
| Subtotal | 493.6 | 1,079.3 | 1,203.9 | 1,303.9 | 1,413.8 | 1,484.0 | 1,747.9 | 1,995.9 | 2,087.6 |
| Processing Industry: | | | | | | | | | |
| Food proc. industry | 583.3 | 704.3 | 761.9 | 839.2 | 843.6 | 888.8 | 988.0 | 1,170.6 | 1,222.1 |
| Food proc. machinery | 2.8 | 22.6 | 19.8 | 19.4 | 19.4 | 19.8 | 23.8 | 23.8 | 23.8 |
| Paper packaging | 33.7 | 58.7 | 67.5 | 79.4 | 103.2 | 111.1 | 123.0 | 141.7 | 150.8 |
| Glass containers | 55.6 | 102.0 | 103.2 | 107.1 | 119.8 | 123.0 | 134.9 | 166.3 | 186.5 |
| Steel aluminum & cans | 150.8 | 221.4 | 246.0 | 292.4 | 338.9 | 341.2 | 361.1 | 445.2 | 484.1 |
| Transport (fuel) | 196.8 | 341.7 | 404.7 | 485.3 | 556.3 | 608.3 | 730.1 | 899.1 | 979.7 |
| Trucks and trailers (mfg.) | 111.1 | 166.7 | 196.4 | 186.5 | 170.6 | 175.4 | 242.0 | 278.6 | 293.6 |
| Subtotal | 1,133.7 | 1,617.0 | 1,799.5 | 2,009.0 | 2,151.8 | 2,267.7 | 2,603.0 | 3,125.2 | 3,340.7 |
| Commercial and Home: | | | | | | | | | |
| Comm. refrig. and cooking | 480.1 | 559.5 | 595.2 | 638.8 | 698.4 | 738.8 | 829.3 | 956.3 | 1,043.6 |
| Refrigeration machinery (home & comm.) | 39.7 | 95.2 | 99.2 | 109.1 | 116.7 | 127.0 | 158.7 | 222.2 | 242.0 |
| Home refrig. and cooking | 572.2 | 730.1 | 802.7 | 904.7 | 1,019.8 | 1,097.5 | 1,369.0 | 1,721.7 | 1,904.6 |
| Subtotal | 1,092.0 | 1,384.8 | 1,497.1 | 1,652.7 | 1,834.8 | 1,963.4 | 2,357.0 | 2,900.2 | 3,190.3 |
| Grand total | 2,719.3 | 4,081.1 | 4,500.5 | 4,965.6 | 5,400.4 | 5,715.1 | 6,708.0 | 8,021.3 | 8,618.4 |

Note: Detail may not add to total because of rounding.

Source: Steinhart, J. S. and C. E. Steinhart, Energy Use in the Food Systems, Science, Vol. 184, April 19, 1974. Original table converted from Kcat. to Btu.

TABLE 2.—ENERGY CONSUMPTION INDICATORS, FOOD SYSTEM AND TOTAL ECONOMY, 1947–70

| Year | Quadrillion Btu | | Food system as a share of total energy input (percent) |
|---|---|---|---|
| | Gross energy input [1] | Food system energy input [2] | |
| 1947 | 33.0 | 4.081 | 12.4 |
| 1950 | 34.0 | 4.500 | 13.2 |
| 1954 | N.A. | 4.966 | |
| 1955 | 39.7 | N.A. | |
| 1960 | 44.6 | 5.715 | 12.8 |
| 1964 | N.A. | 6.708 | |
| 1965 | 53.3 | N.A. | |
| 1968 | 61.7 | 8.021 | 13.0 |
| 1970 | 67.4 | 8.618 | 12.8 |

[1] From Statistical Abstract of the United States, 1973, table 832.
[2] From Steinhart and Steinhart, Energy Use in the Food System, Science, Vol. 184, pp. 307–316, April, 1974.

N.A.—Not available.

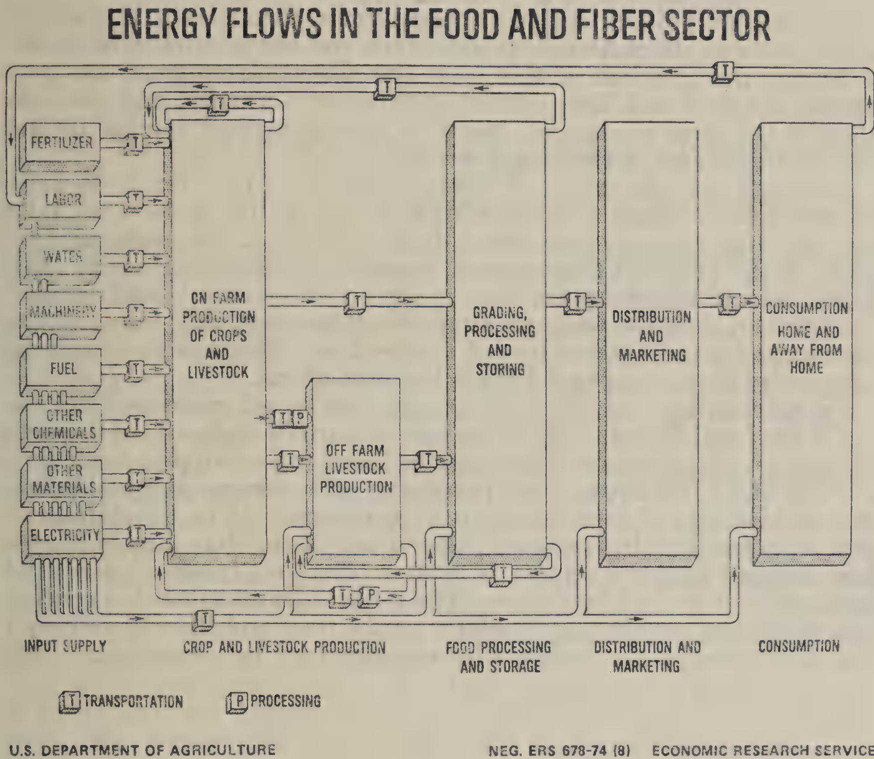


FIGURE 1

Energy needs of the food and fiber system have kept pace with the 4 percent annual growth rate in total U.S. energy consumption during 1950–70. Over the period, food and fiber energy use averaged about 13 percent of the U.S. total (table 2).

Because of this large and growing energy need, the recent energy crisis—including the Arab boycott—has portended serious disruptions to the food system. In fact disruptions have already occurred, dating back to the fall of 1972, when some farmers reported shortages of natural gas and LP gas for crop drying and diesel fuel for fall plowing. During 1973, spot shortages of gasoline and diesel became more widespread and caused farmers problems in production and harvesting. Fuel grew short in rural communities, and many farm accounts were not serviced.

Soon after its creation, the Federal Energy Administration (FEA) recognized the vital importance of fuel to the food and fiber system. In developing the Mandatory Petroleum Allocation Program (MPAP) it granted top priority to agricultural production—100 percent of current needs. And it defined agricultural production more broadly than farming to include processing of perishable products. Actually, it is not just the farm sector that must have sufficient fuel if the food and fiber system is to function as it has in the past. The entire complex depends on the smooth functioning of each of its parts. This interrelation is illustrated in Figure 1; a schematic diagram of the energy flows in the food and fiber sector. An energy shortage in any one of the

subsectors may have serious consequences throughout the entire sector and can affect American consumers and our international trade.

During the first half of this year, the allocation program has permitted the food and fiber system to function normally, and has also allowed the farm production sector to greatly expand acreage in line with national and international needs.

Although the allocation of 100 percent of current needs to agriculture acknowledges the importance of this sector, it does not take into account precisely how much fuel is required. Determining fuel needs in the food and fiber system, however, is difficult. Prior to 1974 fossil fuel and electric power were relatively cheap inputs and detailed statistics on their use were not available. Even now, only fragmentary data exist for most subsectors of the food and fiber system. Such inadequacies have hampered FEA allocation efforts.

To help bridge this information gap, this report examines fuel use in the food and fiber system. It focuses on current fuel and the impacts of higher fuel prices and shortages on farm input supply, farm production and rural living, food processing and storage, and marketing and distribution of farm products to consumers. It traces shifts and trends in practices in fuel use in the various subsectors and estimates fuel demand and the impact of higher prices on future agricultural production and retail food prices. The report also examines the current fuel allocation program as it relates to the food and fiber system and identifies areas in the system where energy may be conserved.

## FARM PRODUCTION AND FAMILY LIVING

Determining the amount of fuel used in farm production separately from that used for family living is an almost impossible task. Most farmers live on the land they operate and the home is an integral part of the operation. The average farmer's office is in his home. Thus a portion of the energy used in his home is for business purposes. He usually lives quite some distance from town and frequently make multipurpose trips involving selling farm products and obtaining inputs or doing grocery shopping on the way to his second job. Some activities are purely business; others purely family living. Some are food and fiber related; others are not.

Compounding the measurement problem is the vast amount of change that has occurred in farming and rural living. Since 1940, more than 20 million people have left the farm and farm employment has declined by more than 6.5 million people. Yet many of those who are no longer farming live in rural communities. Also many farm families, in recent years, have earned more income from nonfarm work than they have from farming [5]. Many farmers work a full-time job in town and still operate their farms. These factors complicate an exact measurement of energy use in the food and fiber system.

### Fuel Used in Farm Production

During the period 1940–73, farm output nearly doubled and output per manhour rose six-fold (table 3). Adoption of new technology—largely fossil fuel using technology—permitted this mass migration of workers from the farm, yet farm production nearly doubled. In 1940, there were still 14.5 million horses and mules on farms and only 1.5 million tractors. Farmers harvested crops from 341 million acres, but products of 43 million acres were used to feed horses and mules. Farm products for domestic use came from 290 million acres. Acreage for exports totaled 8 million acres. In 1973, work stock was a rarity and feed for them would account for less than 1 million acres. Farmers harvested crops from 322 million acres. Products for domestic use came from 226 million acres and we exported the products from 96 million acres (table 4). Currently our farm plant harvests for domestic use about one acre per person while in 1940 domestic use required 2.2 acres per capita.

TABLE 3.—FARM POPULATION, EMPLOYMENT, AND PRODUCTIVITY, 1940–73

[Index, 1967=100]

| Year | Farm population (April 1)[1] | | Farm employment (thousands)[3] | | | Farm output | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Per man-hour | | | |
| | Number (thousands) | As percent of total population[2] | Total | Family workers | Hired workers | Total[4] | Per unit of total input | Total | Crops | Livestock and products | Crop production per acre[5] |
| 1940 | 30,547 | 23.1 | 10,979 | 8,300 | 2,679 | 60 | 62 | 21 | 22 | 27 | 62 |
| 1941 | 30,118 | 22.6 | 10,669 | 8,017 | 2,652 | 62 | 64 | 22 | 24 | 28 | 64 |
| 1942 | 28,914 | 21.4 | 10,504 | 7,949 | 2,555 | 69 | 69 | 24 | 26 | 30 | 70 |
| 1943 | 26,186 | 19.2 | 10,446 | 8,010 | 2,436 | 68 | 68 | 24 | 26 | 32 | 64 |
| 1944 | 24,815 | 17.9 | 10,219 | 7,988 | 2,231 | 70 | 69 | 25 | 27 | 31 | 68 |
| 1945 | 24,420 | 17.5 | 10,000 | 7,881 | 2,119 | 69 | 70 | 27 | 29 | 31 | 68 |
| 1946 | 25,403 | 18.0 | 10,295 | 8,106 | 2,189 | 71 | 72 | 29 | 31 | 32 | 70 |
| 1947 | 25,829 | 17.9 | 10,382 | 8,115 | 2,267 | 69 | 70 | 29 | 31 | 33 | 67 |
| 1948 | 24,383 | 16.6 | 10,363 | 8,026 | 2,337 | 75 | 76 | 32 | 35 | 34 | 75 |
| 1949 | 24,194 | 16.2 | 9,964 | 7,712 | 2,252 | 74 | 73 | 33 | 36 | 36 | 70 |
| 1950 | 23,048 | 15.2 | 9,926 | 7,597 | 2,329 | 73 | 73 | 35 | 39 | 37 | 69 |
| 1951 | 21,890 | 14.2 | 9,546 | 7,310 | 2,236 | 75 | 73 | 36 | 38 | 39 | 69 |
| 1952 | 21,748 | 13.9 | 9,149 | 7,005 | 2,144 | 78 | 76 | 39 | 42 | 40 | 73 |
| 1953 | 19,874 | 12.5 | 8,864 | 6,775 | 2,089 | 79 | 77 | 41 | 43 | 41 | 73 |
| 1954 | 19,019 | 11.7 | 8,651 | 6,570 | 2,081 | 79 | 78 | 43 | 45 | 43 | 71 |
| 1955 | 19,078 | 11.5 | 8,381 | 6,345 | 2,036 | 82 | 81 | 47 | 48 | 46 | 74 |
| 1956 | 18,712 | 11.1 | 7,852 | 5,900 | 1,952 | 82 | 82 | 50 | 52 | 48 | 77 |
| 1957 | 17,656 | 10.3 | 7,600 | 5,660 | 1,940 | 80 | 83 | 53 | 56 | 51 | 77 |
| 1958 | 17,128 | 9.8 | 7,503 | 5,521 | 1,982 | 86 | 89 | 59 | 65 | 55 | 86 |
| 1959 | 16,592 | 9.4 | 7,342 | 5,390 | 1,952 | 88 | 90 | 62 | 66 | 59 | 86 |
| 1960 | 15,635 | 8.7 | 7,057 | 5,172 | 1,885 | 90 | 93 | 67 | 71 | 62 | 88 |
| 1961 | 14,803 | 8.1 | 6,919 | 5,029 | 1,890 | 90 | 94 | 70 | 73 | 67 | 92 |
| 1962 | 14,313 | 7.7 | 6,700 | 4,873 | 1,827 | 91 | 95 | 73 | 77 | 71 | 95 |
| 1963 | 13,367 | 7.1 | 6,518 | 4,738 | 1,780 | 95 | 98 | 80 | 82 | 77 | 97 |
| 1964 | 12,954 | 6.8 | 6,110 | 4,506 | 1,604 | 94 | 97 | 83 | 85 | 83 | 95 |
| 1965 | 12,363 | 6.4 | 5,610 | 4,128 | 1,482 | 97 | 100 | 91 | 92 | 87 | 100 |
| 1966 | 11,595 | 5.9 | 5,214 | 3,854 | 1,360 | 96 | 97 | 94 | 95 | 93 | 99 |
| 1967 | 10,875 | 5.5 | 4,903 | 3,650 | 1,253 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1968 | 10,454 | 5.2 | 4,749 | 3,536 | 1,213 | 102 | 101 | 106 | 106 | 105 | 104 |
| 1969 | 10,307 | 5.1 | 4,596 | 3,420 | 1,176 | 103 | 101 | 112 | 112 | 112 | 107 |
| 1970 | 9,712 | 4.7 | 4,523 | 3,348 | 1,175 | 102 | 101 | 113 | 110 | 119 | 102 |
| 1971 | 9,425 | 4.6 | 4,436 | 3,275 | 1,161 | 110 | 108 | 125 | 122 | 130 | 111 |
| 1972 | 9,610 | 4.6 | 4,373 | 3,227 | 1,146 | 112 | 110 | 131 | 126 | 138 | 115 |
| 1973 | 9,500 | 4.5 | 4,395 | 3,232 | 1,163 | 116 | 112 | 129 | 127 | 127 | 114 |

[1] Farm population as defined by Department of Agriculture and Department of Commerce, i.e., civilian population living on farms, regardless of occupation.
[2] Total population of United States as of July 1 including Armed Forces overseas.
[3] Includes persons doing farmwork on all farms. These data published by the Department of Agriculture, Statistical Reporting Service, differ from those on agricultural employment by the Department of Labor because of differences in the method of approach, in concepts of employment, and in time of month for which the data are collected.
[4] Farm output measures the annual volume of farm production available for eventual human use through sales from farms or consumption in farm households. Total excludes production of seeds and of feed for horses and mules. The Department of Agriculture also estimates net farm output, which excludes all quantities used for feed.
[5] Computed from variable weights for individual crops produced each year.

Sources: Department of Agriculture and Department of Commerce (Bureau of the Census).

TABLE 4.—ACREAGES OF HARVESTED CROPS USED FOR SPECIFIED PURPOSES UNITED STATES, 1940–73

| Year | Crops harvested [1] | Acreage used for producing export products [2] | Acreage used for producing— Feed for horses and mules: On farms | In cities: mines, etc. | Products for domestic use [3]: Total | Per capita | Total population July 1 [4] |
|---|---|---|---|---|---|---|---|
| | Million acres | Million acres | Million acres | Million acres | Million acres | Acres | Millions |
| 1940 | 341 | 8 | 42 | 1 | 290 | 2.20 | 132 |
| 1941 | 344 | 12 | 39 | 1 | 292 | 2.20 | 133 |
| 1942 | 348 | 13 | 38 | 1 | 296 | 2.19 | 135 |
| 1943 | 357 | 21 | 36 | 1 | 299 | 2.18 | 137 |
| 1944 | 362 | 25 | 35 | 1 | 301 | 2.18 | 138 |
| 1945 | 354 | 42 | 31 | 1 | 280 | 2.00 | 140 |
| 1946 | 352 | 45 | 28 | 1 | 278 | 1.97 | 141 |
| 1947 | 355 | 42 | 25 | 1 | 287 | 1.99 | 144 |
| 1948 | 356 | 52 | 23 | 1 | 280 | 1.90 | 147 |
| 1949 | 360 | 45 | 21 | 1 | 293 | 1.97 | 149 |
| 1950 | 345 | 50 | 18 | 1 | 276 | 1.82 | 152 |
| 1951 | 344 | 59 | 17 | 1 | 267 | 1.73 | 154 |
| 1952 | 349 | 36 | 14 | 1 | 298 | 1.90 | 157 |
| 1953 | 348 | 31 | 12 | 1 | 304 | 1.90 | 160 |
| 1954 | 346 | 37 | 10 | 1 | 298 | 1.84 | 162 |
| 1955 | 340 | 47 | 9 | 1 | 283 | 1.72 | 165 |
| 1956 | 324 | 60 | 8 | 1 | 255 | 1.52 | 168 |
| 1957 | 324 | 48 | 7 | 1 | 268 | 1.57 | 171 |
| 1958 | 324 | 44 | 6 | 1 | 273 | 1.57 | 174 |
| 1959 | 324 | 61 | 5 | 1 | 257 | 1.45 | 177 |
| 1960 | 324 | 64 | 4 | 1 | 255 | 1.41 | 181 |
| 1961 | 302 | 67 | (6) | (6) | 235 | 1.28 | 184 |
| 1962 | 294 | 66 | (6) | (6) | 228 | 1.22 | 187 |
| 1963 | 298 | 77 | (6) | (6) | 221 | 1.17 | 189 |
| 1964 | 298 | 74 | (6) | (6) | 224 | 1.17 | 192 |
| 1965 | 299 | 76 | (6) | (6) | 223 | 1.15 | 194 |
| 1966 | 294 | 69 | (6) | (6) | 225 | 1.15 | 196 |
| 1967 | 306 | 69 | (6) | (6) | 237 | 1.19 | 199 |
| 1968 | 300 | 54 | (6) | (6) | 246 | 1.22 | 201 |
| 1969 | 290 | 61 | (6) | (6) | 229 | 1.13 | 203 |
| 1970 | 293 | 72 | (6) | (6) | 221 | 1.08 | 205 |
| 1971 | 305 | 62 | (6) | (6) | 243 | 1.17 | 207 |
| 1972 | 293 | 91 | (6) | (6) | 202 | .97 | 209 |
| 1973 [5] | 322 | 96 | (6) | (6) | 226 | 1.08 | 210 |

[1] Area in principal crops harvested as reported by SRS plus acreages in fruits, tree nuts, and farm gardens.
[2] Acreages for exports relate to exports for year beginning July 1, or month representing beginning of crop season. Acreage includes seeds for crops and feed for livestock that are exported.
[3] Includes products used by our military forces in this country and abroad, and by our domestic civilian population. Includes feed for horses and mules since 1961.
[4] Includes persons in our military forces in this country and abroad.
[5] Preliminary.
[6] No data available, but probably less than one million acres.

We have been able to provide ourselves with this immense abundance of food and fiber with fewer people and less land through increased technology. This country has invested billions in research and extension of knowledge in farming. We have developed hybrid seed that increased yields substantially. We have supplemented and largely supplanted animal manure with low cost commercial fertilizer, mainly nitrogen fertilizer produced by snythesizing ammonia from natural gas. Over time, technology reduced production costs of fertilizer relative to other inputs. Farmers responded by using more fertilizer. And, crop production per acre rose sharply—about 85 percent above the 1940 level (table 3). Aiding in this productivity increase is the use of chemical pestidices—fungicides, herbicides, and insecticides—which protect crops and livestock from insects, disease, and competing weeds. These technological developments would be of limited value to farmers, however, without modern equipment and fuels to prepare the land, apply the production inputs and harvest the output in a timely manner.

From 1940 to 1972 tractor horsepower rose sixfold, the quantity of fuel increased fourfold and petroleum expenditures rose fivefold. Farming had become fossil fuel energy intensive. However, the petroleum proportion of total inputs decreased steadily since 1950 as prices and/or quantities of other inputs increased faster than for petroleum. By 1973, petroleum fuel represented only about 3 percent of total farm production expenses (table 5).

In contrast with the total economy, farm production relies heavily on energy from petroleum—gasoline, diesel fuel, and LP gas. Use of coal and natural gas in farm production is inconsequential. However, considerable natural gas is used in heating farm homes. The proportion of energy from electricity to total energy consumption is about double that of the total economy, but nearly two-thirds of this is for farm household use so that electricity used for production purposes is likely little different than the proportion used for the total economy (table 6).

In 1969 about 2.6 million farms reported spending $1.9 billion on petroleum fuel for the farm business. Farmers used about 7.1 million gallons of gasoline, diesel, and LP gas in 1969 compared with a total domestic consumption of 221 billion gallons. Thus, farming accounted for about 3 percent of all petroleum usage [5]. By 1973, farming accounted for about 8 billion gallons. This increase was less than proportional to the total fuel consumption.

TABLE 5.—FUEL AS A FARM PRODUCTION INPUT, SELECTED YEARS, 1940–1973

[Dollar amounts in millions]

| Year | Total production expenses [1] | Petroleum fuel and oil [2] | Percent fuel of total |
|---|---|---|---|
| 1940 | $6,858 | $350 | 5.1 |
| 1950 | 19,455 | 1,191 | 6.1 |
| 1960 | 27,418 | 1,484 | 5.4 |
| 1964 | 31,715 | 1,567 | 4.9 |
| 1969 | 42,180 | 1,717 | 4.1 |
| 1970 | 44,572 | 1,711 | 3.8 |
| 1971 | 47,603 | 1,722 | 3.6 |
| 1972 | 52,428 | 1,688 | 3.2 |
| 1973 | 64,746 | 1,879 | 2.9 |

[1] Including Government payments to nonfarm landlords.
[2] For farm business use.

Source: USDA–ERS–FIS–222, July, 1974.

TABLE 6.—CONSUMPTION OF MINERAL FUEL RESOURCES AND ELECTRICITY, TOTAL ECONOMY AND FARM PRODUCTION USE, 1940 TO 1972

TOTAL ECONOMY[1]

| Year | Total (trillion Btu) | Percent of total: Coal | Crude petroleum | Natural gas | Electricity | Percent of 1960 |
|---|---|---|---|---|---|---|
| 1940 | 23,908 | 52.4 | 31.4 | 12.4 | (NA) | 53.6 |
| 1950 | 34,153 | 37.8 | 37.2 | 20.3 | (NA) | 76.6 |
| 1960 | 44,569 | 22.8 | 41.8 | 31.7 | 3.7 | 100.0 |
| 1965 | 53,343 | 22.3 | 40.1 | 33.7 | 3.9 | 119.7 |
| 1970 | 67,143 | 18.9 | 40.3 | 36.5 | 4.3 | 150.6 |
| 1971 | 68,728 | 17.6 | 40.8 | 36.8 | 4.8 | 154.2 |
| 1972 | 72,378 | 17.2 | 41.9 | 35.9 | 5.0 | 162.4 |

FARM PRODUCTION USE[2]

| Year | Total (trillion Btu) | Percent: Coal | Crude petroleum | LP gas[3] | Electricity[4] | Percent of 1959 |
|---|---|---|---|---|---|---|
| 1947 | 628 | | 91.4 | (6.7) | 8.6 | 80.4 |
| 1953 | 750 | | 90.1 | (5.6) | 9.9 | 96.0 |
| 1959 | 781 | | 86.2 | (5.0) | 13.8 | 100.0 |
| 1964 | 952 | | 88.0 | (11.5) | 12.0 | 121.9 |
| 1969 | 1,072 | | 88.4 | (10.7) | 11.6 | 137.3 |
| 1970 | (NA) | | (NA) | (NA) | (NA) | (NA) |
| 1971 | 1,121 | | 88.3 | (9.9) | 11.7 | 143.5 |
| 1972 | (NA) | | (NA) | (NA) | (NA) | (NA) |
| 1973 | 1,200 | | 88.5 | (9.7) | 11.5 | 153.6 |

[1] From Table 830, Statistical Abstract of the United States, 1973.
[2] Developed from secondary data USDA-ERS.
[3] Included under crude petroleum. Separated to show importance in farm production. No natural gas data available.
[4] Includes home use.

NA—Not available.

TABLE 7.—ENERGY PURCHASED BY FARMERS: COST PER UNIT AND PER MILLION BTU, SELECTED YEARS, 1951–73

| Year | Coal, anthracite (ton) | Diesel fuel (gallons) | Gasoline[1] Bulk (gallons) | Gasoline[1] Station (gallons) | Kerosene (gallons) | Furnace fuel oil (gallons) | LP gas[2] (gallons) | Natural gas[3] (thousand cubic ft.) | Electricity (kilowatt hour) |
|---|---|---|---|---|---|---|---|---|---|
| | Dollars per unit | | | | | | | | |
| 1951 | 23.00 | .155 | NA | .222 | .190 | NA | NA | .298 | .0292 |
| 1955 | 23.70 | .161 | .210 | .253 | .186 | NA | NA | .400 | .0261 |
| 1960 | 24.80 | .162 | .236 | .277 | .184 | .159 | NA | .501 | .0220 |
| 1965 | 25.80 | .165 | .233 | .274 | .189 | .162 | .124 | .522 | .0227 |
| 1970 | 30.10 | .181 | .262 | .309 | .204 | .175 | .147 | .536 | .0212 |
| 1971 | 31.40 | .189 | .268 | .315 | .210 | .181 | .156 | .577 | .0218 |
| 1972 | 32.40 | .190 | .270 | .314 | .212 | .183 | .156 | .621 | .0223 |
| 1973 | NA | .227 | .297 | .347 | .246 | .221 | .169 | NA | .0231 |
| | Dollars per million Btu | | | | | | | | |
| 1951 | .906 | 1.12 | NA | 1.77 | 1.41 | NA | NA | .29 | 8.79 |
| 1955 | .933 | 1.16 | 1.68 | 2.02 | 1.38 | NA | NA | .39 | 7.65 |
| 1960 | .976 | 1.17 | 1.89 | 2.21 | 1.36 | 1.15 | NA | .48 | 6.45 |
| 1965 | 1.02 | 1.19 | 1.86 | 2.19 | 1.40 | 1.17 | 1.36 | .50 | 6.65 |
| 1970 | 1.19 | 1.31 | 2.09 | 2.47 | 1.51 | 1.26 | 1.61 | .52 | 6.21 |
| 1971 | 1.24 | 1.37 | 2.14 | 2.52 | 1.56 | 1.31 | 1.70 | .56 | 6.39 |
| 1972 | 1.28 | 1.37 | 2.16 | 2.51 | 1.57 | 1.32 | 1.70 | .60 | 6.54 |
| 1973 | NA | 1.64 | 2.37 | 2.77 | 1.82 | 1.59 | 1.85 | NA | 6.77 |

[1] $0.04 per gallon deducted from reported price to account for estimated Federal and State tax refunds for non-highway uses.
[2] Assumed propane for conversion purposes.
[3] U.S. average price at point of consumption, USDI-BOM, Minerals Yearbook; Metals, Minerals, and Fuels, selected issues

NA—Not available.

Source: Adapted from USDA-ERS, Prices Paid by Farmers, selected issues.

TABLE 8.—FARM FUEL CONSUMPTION: ESTIMATED USE BY MAJOR FARM POWER ITEMS BY REGION, UNITED STATES, 1973[1]

| | North-east | Lake States | Corn Belt | North-ern Plains | Appa-lachian | South-east | Delta States | South-ern Plains | Moun-tain | Pacific | United States |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tractors: | | | | | | | | | | | |
| Gasoline | 136 | 287 | 637 | 267 | 164 | 67 | 70 | 118 | 82 | 75 | 1,903 |
| Diesel | 65 | 163 | 391 | 348 | 123 | 163 | 281 | 312 | 185 | 309 | 2,340 |
| Combines: | | | | | | | | | | | |
| Gasoline | 6 | 22 | 76 | 59 | 13 | 9 | 25 | 28 | 21 | 32 | 291 |
| Diesel | 1 | 1 | 4 | 3 | 1 | 1 | 1 | 1 | 2 | 10 | 25 |
| Other machines: | | | | | | | | | | | |
| Gasoline | 9 | 15 | 20 | 19 | 12 | 9 | 12 | 19 | 15 | 28 | 158 |
| Diesel | | 4 | | 16 | 1 | 4 | 5 | 10 | 3 | 15 | 58 |
| Automobiles: | | | | | | | | | | | |
| Gasoline[2] | 21 | 38 | 88 | 38 | 55 | 26 | 19 | 34 | 19 | 24 | 362 |
| Trucks: | | | | | | | | | | | |
| Gasoline | 61 | 81 | 206 | 136 | 165 | 131 | 101 | 188 | 101 | 139 | 1,309 |
| Diesel | 3 | | 10 | 1 | 4 | 4 | 8 | 7 | 5 | 12 | 54 |
| Total | 302 | 611 | 1,432 | 887 | 538 | 414 | 522 | 717 | 433 | 644 | 6,500 |
| Gasoline | 233 | 443 | 1,027 | 519 | 409 | 242 | 227 | 387 | 238 | 298 | 4,023 |
| Diesel | 69 | 168 | 405 | 368 | 129 | 172 | 295 | 330 | 195 | 346 | 2,477 |

[1] Estimated in ERS.
[2] Portion for farm business only.

The prices farmers pay for different kinds of energy vary as much as tenfold per Btu. In 1972, natural gas from utility companies cost $0.60 per million Btu compared with electricity at $6.54 (table 7). The low price of LP gas in relation to electricity, about one-fourth, is likely the reason most farmers have installed LP gas crop dryers rather than electric dryers. During the propane shortage of 1973, electric crop dryers remained available but high operating costs deterred many farmers from purchasing them. Propane prices could have risen threefold and still left propane more economical than electricity for crop drying.

*Gasoline and Diesel*

Of the 8 billion gallons of fuel used in 1973, 6.5 billion were gasoline and diesel. Tractors were the major users of fuel consuming 1.9 billion gallons of gasoline and 2.3 billion gallons of diesel fuel (table 8). Farm trucks used over 1.3 billion gallons of gasoline and little diesel. Combines used nearly 300 million gallons of gasoline. While small in total gallons, diesel fuel amounted to 8 percent of total fuel used in combines. The 362 million gallons used in automobiles for business purposes represents only 25 percent of the total gasoline consumed by farm autos in 1973—1.45 billion gallons.

The Corn Belt region used nearly one-fourth of this fuel. See figure 2 for States in regions.

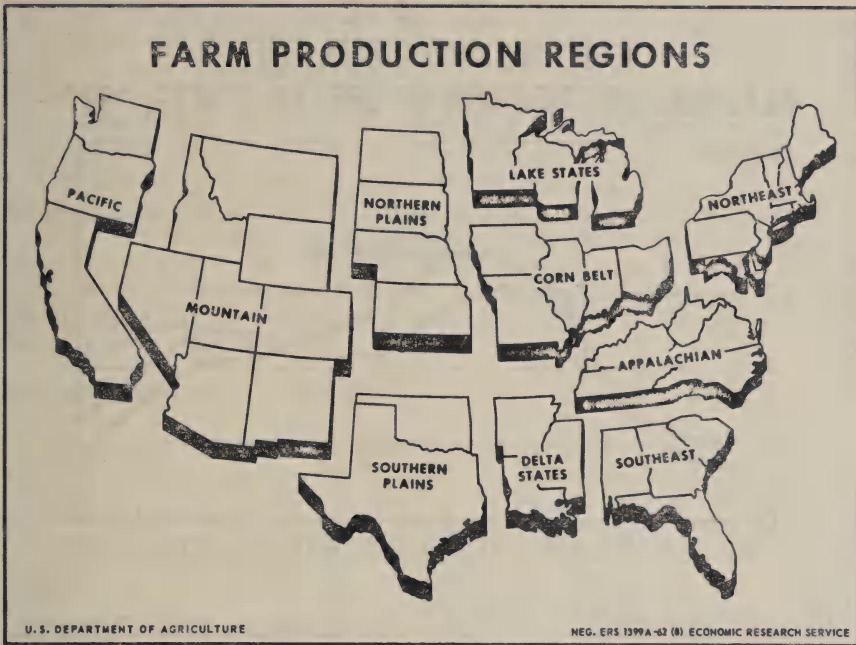


FIGURE 2

It is the large diesel tractors that do the bulk of the land fitting and planting. It is imperative that they have an adequate supply of diesel fuel available to them at time of need. Any delay in getting a crop planted beyond the optimum planting date has a depressing effect on yields. Therefore, production will be less than desired and be more costly, from a unit standpoint. In the central Corn Belt, for example, with each days' delay in planting corn, yield will drop a bushel a day from May 1 through May 15, and 2 bushels a day from May 15 to the end of May, yet input costs remain constant.

For 1972, May and June were peak months for gasoline consumption, and May for diesel fuel peak use. January was the month of lowest consumption (figure 3 and table 9). While gasoline consumption peaks in May and June and declines each month thereafter, diesel fuel consumption has two peaks—May and October. This second peak reflects the heavy duty operations performed in the fall—crop residue chopping, disking and plowing.

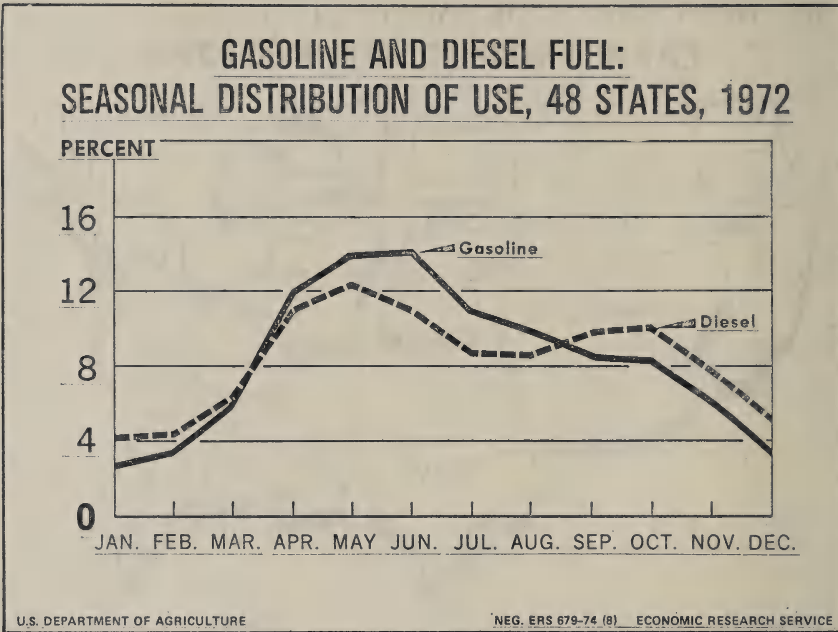


FIGURE 3

Fuel use in farming, however, is highly variable and dependent upon the season. A cold wet spring will delay land preparation and planting. Yet as soon as the weather turns favorable, farmers will rush, day and night, to get their crops planted. Many will take short cuts including reduced tillage practices in an effort to catch up with their work. This will compress the normal planting period. As the season progresses, weather will affect growing conditions and may hasten or delay maturity of a crop by as much as two or three weeks. Thus, determining seasonal farm fuel consumption patterns with precision is impossible.

Seasonality patterns of fuel use also differ sharply among regions. In the Southeast, winter fruit and vegetable production in Florida causes that region's fuel pattern to be heavy during February through June, with peak use occurring in April. In the Northern Plains, fuel use in January and February is minimal and peak use does not occur until June with the start of small grain harvest.

During periods of fuel shortage potential conflicts arise in a number of regions between providing diesel fuel to operate tractors and providing fuel oil to heat homes. These two fuels are generally substitutable. In all but three Southern regions farmers are still using large quantities of diesel fuel as the home heating season commences.

*LP gas*

Unlike gasoline and diesel, LP gas use on farms represents a substantial proportion of total LP gas sales. In 1971, farms purchased 17 percent of LP gas sold. Of the total propane sales alone, farmers purchased 22 percent for both home and farm production use.

LP gas demand for farm production alone is estimated at about 1.3 billion gallons or 8 percent of total LP gas sales for 1973 (table 10). This estimate is based on an average fall with good natural crop drying conditions. By farm production regions, greatest LP gas demand is

in the Southern Plains and the Corn Belt. Over time, the use of LP gas in the Corn Belt has been increasing—reflecting increased crop drying—mainly corn and soybeans.

LP gas is used on farms for a number of purposes, including fuel for motors, for drying crops and for brooding poultry and livestock. In 1971, 54 percent of the LP gas used in farming was for motor purposes while 46 percent was used for nonmotor purposes (table 11). However, LP gas use in farm motors has been declining in recent years as sales of most LP gas powered units have declined sharply—irrigation pumps are an exception. The decreasing demand for LP gas for motor use has been offset by increasing use for nonmotor purposes, such as crop drying, tobacco curing, and space heating of broiler houses and young livestock housing [17].

TABLE 9.—MONTHLY DISTRIBUTION OF GASOLINE AND DIESEL FUEL USED FOR FARM PRODUCTION, BY REGIONS, 1972[1]

[In percent]

| Region | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GASOLINE | | | | | | | | | | | | | |
| Northeast | 3.6 | 3.4 | 4.6 | 9.9 | 14.0 | 15.5 | 12.0 | 9.9 | 9.9 | 8.2 | 5.5 | 3.5 | 100.0 |
| Lake States | 2.5 | 2.7 | 3.6 | 10.5 | 15.0 | 15.3 | 11.4 | 10.1 | 9.9 | 9.3 | 6.5 | 3.2 | 100.0 |
| Corn Belt | 2.4 | 2.9 | 4.9 | 13.9 | 15.9 | 13.8 | 10.4 | 8.0 | 8.2 | 8.9 | 7.6 | 3.1 | 100.0 |
| Northern Plains | 2.2 | 2.4 | 4.9 | 10.7 | 13.4 | 15.1 | 14.5 | 10.6 | 9.0 | 8.4 | 6.0 | 2.8 | 100.0 |
| Appalachian | 2.4 | 3.4 | 6.9 | 13.1 | 15.0 | 15.5 | 12.8 | 8.8 | 8.6 | 6.2 | 4.6 | 2.7 | 100.0 |
| Southeast | 4.8 | 7.2 | 11.6 | 14.5 | 14.1 | 12.2 | 7.4 | 6.2 | 6.2 | 6.2 | 5.7 | 3.9 | 100.0 |
| Delta States | 3.6 | 3.6 | 10.2 | 14.3 | 15.1 | 13.5 | 8.6 | 6.9 | 6.9 | 7.4 | 6.3 | 3.6 | 100.0 |
| Southern Plains | 3.8 | 4.0 | 8.9 | 10.6 | 12.6 | 13.4 | 11.1 | 8.4 | 8.4 | 8.2 | 6.4 | 4.2 | 100.0 |
| Mountain | 2.8 | 2.8 | 6.2 | 12.0 | 13.6 | 13.2 | 12.4 | 11.1 | 9.5 | 8.5 | 5.0 | 2.9 | 100.0 |
| Pacific | 3.5 | 4.3 | 6.4 | 10.5 | 11.0 | 12.2 | 11.1 | 10.0 | 12.0 | 9.0 | 5.9 | 4.1 | 100.0 |
| United States | 2.9 | 3.4 | 6.3 | 12.3 | 14.4 | 14.6 | 10.8 | 8.9 | 8.5 | 8.3 | 6.3 | 3.3 | 100.0 |
| DIESEL | | | | | | | | | | | | | |
| Northeast | 3.4 | 2.8 | 2.9 | 7.1 | 10.7 | 11.6 | 11.8 | 12.1 | 14.2 | 13.2 | 6.1 | 4.1 | 100.0 |
| Lake States | 2.6 | 2.2 | 3.1 | 9.2 | 11.5 | 9.2 | 5.9 | 7.6 | 12.3 | 18.4 | 10.8 | 7.2 | 100.0 |
| Corn Belt | 2.6 | 2.9 | 6.2 | 18.0 | 19.1 | 11.1 | 5.9 | 5.7 | 6.7 | 9.7 | 7.6 | 4.5 | 100.0 |
| Northern Plains | 1.6 | 2.4 | 4.7 | 10.1 | 11.9 | 15.7 | 11.7 | 12.2 | 10.4 | 9.7 | 6.6 | 3.0 | 100.0 |
| Appalachian | 4.8 | 2.2 | 3.7 | 6.6 | 8.1 | 7.8 | 7.4 | 6.9 | 15.3 | 15.1 | 13.6 | 8.5 | 100.0 |
| Southeast | 5.8 | 7.8 | 13.1 | 16.9 | 16.2 | 8.4 | 5.7 | 5.3 | 4.9 | 5.5 | 5.8 | 4.6 | 100.0 |
| Delta States | 5.2 | 6.3 | 10.5 | 14.0 | 14.5 | 8.8 | 7.9 | 6.8 | 7.0 | 7.3 | 6.4 | 5.3 | 100.0 |
| Southern Plains | 3.5 | 5.1 | 9.5 | 10.7 | 11.2 | 15.0 | 12.4 | 11.2 | 8.6 | 5.7 | 3.3 | 3.8 | 100.0 |
| Mountain | 3.1 | 3.6 | 4.6 | 8.9 | 10.4 | 12.7 | 8.9 | 8.6 | 11.3 | 10.9 | 10.4 | 6.6 | 100.0 |
| Pacific | 6.6 | 4.9 | 5.6 | 8.6 | 8.8 | 7.4 | 7.3 | 6.6 | 11.2 | 12.0 | 11.9 | 9.1 | 100.0 |
| United States | 3.9 | 4.0 | 6.4 | 11.1 | 12.2 | 11.0 | 8.6 | 8.3 | 10.0 | 10.4 | 8.3 | 5.8 | 100.0 |

[1] Estimated from secondary data, NEAD-ERS.

TABLE 10.—LP GAS USE IN FARM PRODUCTION BY REGIONS, 1964, 1969, 1971, AND ESTIMATES FOR 1973[1]

| Region | LPG use (thousand gallons) | | | | Change from 1971 to 1973 (percent) |
|---|---|---|---|---|---|
| | 1964 | 1969[2] | 1971 | Estimated 1973 | |
| Northeast | 21,654 | 29,075 | 30,518 | 31,366 | 2.8 |
| Lake States | 39,409 | 70,147 | 78,516 | 83,548 | 6.4 |
| Corn Belt | 122,698 | 204,777 | 226,293 | 249,182 | 10.1 |
| Northern Plains | 147,882 | 175,563 | 177,748 | 177,063 | −.4 |
| Appalachian | 44,620 | 74,105 | 81,808 | 81,047 | −.9 |
| Southeast | 73,607 | 89,578 | 91,395 | 90,600 | −.9 |
| Delta States | 157,807 | 146,307 | 134,958 | 133,123 | −1.4 |
| Southern Plains | 447,890 | 330,231 | 269,681 | 295,732 | 9.7 |
| Mountain | 85,101 | 82,936 | 78,162 | 78,764 | .8 |
| Pacific | 48,905 | 41,447 | 36,632 | 43,592 | 19.0 |
| 48 States | 1,189,573 | 1,244,166 | 1,205,711 | 1,264,017 | 4.8 |

[1] Sources: U.S. Census of Agriculture, 1964, 1969, and 1971 SRS Farm Expenditure Survey.
[2] Adjusted to include all farms.

Major problems in making adequate supplies of LP gas available for farm use are the highly seasonal variations in agricultural demand and the annual variation in weather. About 50 percent of the farm production use of LP gas in the United States occurs during the last 4 months of the year. However, extreme seasonal peaking in the month of November typifies the demand for LP gas in corn drying. In the Corn Belt, as much as 90 percent of the annual use may occur during October through December due to extensive corn drying. Thus as one might expect, seasonality of agricultural use of LP gas varies by regions.

The principal concern for agricultural use during the fall months centers in the Midwest—the Lake States, Corn Belt, and portions of States in the Northern Plains—where corn, grain sorghum, and soybean crop drying needs occur at the same time as home heating needs begin to increase.

In contrast, tobacco curing in the Appalachian and Southeast regions causes LP gas consumption to peak during July and August. Only about 20 percent of farm production needs occur in the last 4 months of the year for these two regions.

In the Delta States, Southern Plains, and Pacific regions, motor uses account for most LP gas farm production consumption, and seasonal peaking is less evident.

The use of LP gas in grain drying—especially corn—has increased rapidly because farmers have switched from harvesting corn in the ear to the more economical field-shelling method and are harvesting earlier to reduce the uncertainty of losses from field dried grain. Also, shelled corn is more easily handled than ear corn and the greatly reduced volume harvested saves labor and fuel.

The conversion to field-shelling technology—combines and picker-shellers—has been rapid. From 1960 to 1972, field shelling in the Corn Belt increased from 15 to 77 percent of corn acreage. The shift has occurred in other areas too—62 percent of U.S. corn acreage was harvested as shelled grain in 1969 as compared with 69 percent in the Corn Belt.

Artificial drying has increased accordingly. About half of the corn was dried on the farm in 1973 and nearly all of this required LP gas. About 20 percent of the corn was dried off the farm and about half of this required LP gas and the remainder required mostly natural gas. This increase in heated-air crop drying is reflected in the magnitude of crop dryer shipments (table 12).

TABLE 11.—PROPORTION OF LP GAS USED IN MOTORS AND FOR OTHER PURPOSES ON FARMS IN UNITED STATES BY REGION, 1971

[In percent]

| Farm production region | Motor uses | Other uses |
|---|---|---|
| Northeast | 15 | 85 |
| Lake States | 7 | 93 |
| Corn Belt | 21 | 79 |
| Northern Plains | 65 | 35 |
| Appalachian | 10 | 90 |
| Southeast | 25 | 74 |
| Delta States | 83 | 17 |
| Southern Plains | 88 | 12 |
| Mountain | 72 | 27 |
| Pacific | 80 | 20 |
| United States | 54 | 46 |

Source: 1971 SRS farm production expenditure survey.

TABLE 12.—AGRICULTURAL CROP DRYER SHIPMENTS, 1961-72

| Year | Grain, hay and seed dryers: Heated types [1] | Grain, hay and seed dryers: Unheated air types | Total | Tobacco curers, heated types [2] |
|---|---|---|---|---|
| 1961 | 7,815 | 10,926 | 18,741 | (NA) |
| 1962 | 6,836 | 7,695 | 14,531 | (NA) |
| 1963 | 6,161 | 5,446 | 11,607 | (NA) |
| 1964 | 6,061 | 5,169 | 11,230 | (NA) |
| 1965 | 11,801 | 8,024 | 19,825 | (NA) |
| 1966 | 14,904 | 2,535 | 17,439 | (NA) |
| 1967 | 15,278 | 2,083 | 17,361 | (NA) |
| 1968 | 17,318 | 925 | 18,243 | 8,538 |
| 1969 | 10,103 | 1,519 | 11,622 | 8,936 |
| 1970 | 7,153 | 2,019 | 9,172 | 11,089 |
| 1971 | 13,517 | 2,279 | 15,796 | ---------- |
| 1972 | 16,456 | 3,358 | 19,814 | 7,337 |

[1] Consists of batch, continuous flow, heated air and supplemental heater units estimated by manufacturers to be 90 to 95 percent LP gas fueled.
[2] An estimated 70 percent of tobacco curers are LP gas fueled.
NA—Not available.

Source: USDC-Current Industrial Reports, M35-A, selected issues.

In addition to the large and increasing use of LP gas for drying corn, moderate amounts of LP gas are used in drying wheat, soybeans, rice, grain sorghum, and other small grains. LP gas is also used for drying peanuts during a two or three week harvest period; and it is used extensively in curing tobacco.

*Electricity*

Farmers use of electricity has tripled since 1950 when only 77 percent of the farms had electric service (table 13). In 1973, over 40 billion kilowatt hours were used on farms. However, much of this was consumed in family living. In 1970, farm family living purposes used 64 percent of the electricity servicing farms. Thus, only 13.4 billion kwh. were used for such production purposes as powering milking machines, feed mills, elevators, augers, welders, heating lamps, and countless other labor saving devices.

Projecting electricity use to 1980 indicates that farmers will utilize 41.5 billion kwh. or 3.2 percent more than in 1973. Of this total, farm production will take 17.7 billion kwh. or a third more than in 1970.

## Farm Production Fuel Demand in 1980

Projected changes in fuel demand for farm production purposes are based on (1) acres of crops and numbers of livestock required to produce the food and fiber needed to satisfy domestic and export needs, and (2) changes in fuel use per unit of production associated with changes in production technology.

Domestic food and fiber requirements are based on the expected population level, disposable personal income, and per capita consumption levels. The U.S. civilian population level is assumed at 224.1 million by 1980, an increase of 15.9 million over 1972. Incomes are expected to continue to rise so that the 1980 per capita consumption level of meats will increase while cereals will remain constant (table 14).

Two scenarios for exports of U.S. farm production were assumed. Depending on the availability of fuel and its price, there might be substantial deviations from the world supply, demand, and trade projections underlying the assumed U.S. export levels used in this report.

The low export scenario assumes a return to longer-run trends from the current high export levels, and that high fuel prices will have

substantial impact on foreign exchange reserves of major agricultural product importing countries restricting their ability to import our farm products.

TABLE 13.—ELECTRICITY: ESTIMATED USE ON FARMS, 1950-73 AND PROJECTED TO 1980

| Year | Number of farms [1] (thousands) | Percent electrified [2] | Number farms electrified (thousands) | Monthly kilowatt hours per farm [3] | Annual kilowatt hours per farm | Total kilowatt hours (millions) |
|---|---|---|---|---|---|---|
| 1950 | 5, 648 | 77. 2 | 4, 360 | 250E | 3, 000E | 13, 080 |
| 1951 | 5, 428 | 84. 2 | 4, 570 | 275E | 3, 300E | 15, 081 |
| 1952 | 5, 198 | 88. 1 | 4, 579 | 319 | 3, 828 | 17, 528 |
| 1953 | 4, 984 | 90. 8 | 4, 525 | 365 | 4, 380 | 19, 820 |
| 1954 | 4, 798 | 92. 3 | 4, 429 | 417 | 5, 004 | 22, 163 |
| 1955 | 4, 654 | 93. 4 | 4, 347 | 443 | 5, 316 | 23, 109 |
| 1956 | 4, 514 | 94. 2 | 4, 252 | 466 | 5, 592 | 23, 777 |
| 1957 | 4, 372 | 94. 8 | 4, 145 | 477 | 5, 724 | 23, 726 |
| 1958 | 4, 233 | 95. 4 | 4, 038 | 543 | 6, 516 | 26, 312 |
| 1959 | 4, 105 | 96. 0 | 3, 941 | 642 | 7, 704 | 30, 361 |
| 1960 | 3, 963 | 96. 5 | 3, 824 | 707 | 8, 484 | 32, 443 |
| 1961 | 3, 825 | 96. 8 | 3, 703 | 742 | 8, 904 | 32, 972 |
| 1962 | 3, 692 | 97. 6 | 3, 603 | 765 | 9, 180 | 33, 076 |
| 1963 | 3, 572 | 97. 9 | 3, 497 | 790 | 9, 480 | 33, 152 |
| 1964 | 3, 457 | 98. 1 | 3, 391 | 805 | 9, 660 | 32, 757 |
| 1965 | 3, 356 | 98. 2 | 3, 296 | 823 | 9, 876 | 32, 551 |
| 1966 | 3, 257 | 98. 3 | 3, 202 | 861 | 10, 332 | 33, 083 |
| 1967 | 3, 162 | 98. 4 | 3, 111 | 891 | 10, 692 | 33, 263 |
| 1968 | 3, 071 | 98. 4 | 3, 022 | 941 | 11, 292 | 34, 124 |
| 1969 | 2, 999 | 98. 4 | 2, 951 | 1, 010 | 12, 120 | 35, 766 |
| 1970 | 2, 954 | 98. 4 | 2, 907 | 1, 056 | 12, 672 | 36, 838 |
| 1971 | 2, 909 | 98. 4 | 2, 862 | 1, 102 | 13, 224 | 37, 847 |
| 1972 | 2, 870 | 98. 5 | 2, 827 | 1, 158 | 13, 896 | 39, 284 |
| 1973 [4] | 2, 821 | 98. 5 | 2, 779 | 1, 206 | 14, 472 | 40, 218 |

[1] USDA–SRS, SpSy 3, Number of Farms and Land in Farms selected issues.
[2] Percentages from USDA-ERS.
[3] USDA–SRS, Agricultural Prices, November issues, reported estimate increased by 15 percent to more nearly reflect average monthly consumption.
[4] Preliminary.

E—Estimate.

TABLE 14.—U.S. CIVILIAN PER CAPITA CONSUMPTION OF SPECIFIED FOODS, 1969–71 AVERAGE, 1973, AND PROJECTIONS FOR 1980

[In pounds]

| Commodity | 1969–71 average | 1973 preliminary | 1980 projected |
|---|---|---|---|
| Beef and veal [1] | 115. 5 | 111. 6 | 135. 0 |
| Pork [1] | 68. 1 | 61. 1 | 69. 0 |
| Lamb and mutton [1] | 3. 3 | 2. 8 | 2. 0 |
| Chicken [2] | 40. 7 | 41. 9 | 48. 1 |
| Turkey [2] | 8. 3 | 8. 5 | 10. 5 |
| Eggs | 40. 8 | 38. 3 | 39. 0 |
| Dairy [3] | 563. 0 | 563. 0 | 530. 0 |
| Wheat (grain equivalent) | 152. 6 | 151. 3 | 148. 6 |
| Rice (rough basis) [4] | 9. 7 | 9. 3 | 13. 2 |
| Corn (grain only) | 61. 1 | 64. 3 | 64. 5 |
| Oats | 7. 0 | 7. 0 | 7. 0 |
| Peanuts (farmers stock basis) | 7. 8 | 8. 2 | 8. 5 |
| Food fats and oils (fat content): | | | |
| Animal | 14. 4 | 13. 2 | 11. 4 |
| Vegetable | 38. 7 | 39. 6 | 46. 6 |
| Fruit: [5] | | | |
| Citrus | 93. 1 | 104. 0 | 109. 5 |
| Noncitrus | 101. 1 | 99. 2 | 100. 3 |
| Vegetables: [5] | | | |
| Fresh | 99. 0 | 95. 6 | 10. 5 |
| Canned and frozen | 114. 4 | 115. 8 | 125. 5 |
| Melons [5] | 22. 9 | 22. 0 | 21. 1 |
| Potatoes [5] | 118. 1 | 120. 0 | 127. 0 |
| Sweet potatoes | 4. 0 | 5. 4 | 4. 8 |
| Dry edible beans and peas [6] | 6. 5 | 6. 3 | 6. 0 |

[1] Carcass weight.
[2] Ready-to-cook.
[3] Milk equivalent.
[4] Historical data excluded territories which have high per capita rates: beginning in 1972, data include shipments to territories.
[5] Fresh equivalent.
[6] Cleaned basis.

Source: Food, Consumption, Prices, Expenditures, Agri. Econ. Report No. 138, and Supplement—1971, ERS, USDA, August, 1972.

It further assumes the enlarged European Community would move towards self-sufficiency; the USSR would return to self-sufficiency from current high levels of imports; Eastern Europe would move to a lower level of imports; the developing nations would demand only moderate amounts of grain; and Public Law 480 shipments would continue at low level.

The high export scenario would occur if relative fuel prices return to the 1972–73 level; the USSR and Eastern Europe significantly increase livestock production by importing grain and oil seeds; the People's Republic of China imports more grain to improve diets in urban areas; the enlarged European Community continues significant imports despite the drive toward self-sufficiency; and if the livestock economies in the developing nations expand.

Crop yields are projected to continue on their historical uptrends as farmers adopt improved seed varieties, more efficient use of fertilizers, more efficient machinery, and other improved cultural practices. Corn yields are projected at 115 bushels in 1980, compared with the 91 bushel average in 1973; wheat yields at 36 bushels, compared with 32; soybean yields at 31.5 bushels, compared with 27.8 in 1973; and cotton yields at 520 pounds, compared with 519 pounds.

In 1980, fewer acres will be needed to fulfill total demand requirements than in 1973 when about 371 million acres were harvested (table 15). The lower export scenario will require 354 million acres and the higher export scenario will require 365 million acres.

Under both export alternatives, fewer acres will be needed to fulfill total demand requirements for wheat, other grains, peanuts, cotton, and hay. Under the higher export scenario, acreage of corn, grain sorghum, and soybeans will exceed the 1973 acreage. Under the low export alternative, of major crops, only soybean acreage would exceed the 1973 level and only slightly.

In 1980 about 10 percent more beef cows and cattle, but fewer dairy cows, will be needed to fulfill demand requirements. Broiler and chicken marketing will need to be up about a fourth, and turkeys nearly a fifth. Hog sales are projected to increase about 15 percent, but sales of sheep and lambs will be down about a third.

TABLE 15.—GASOLINE, DIESEL AND LP FUEL [1] USED IN FARM PRODUCTION, BY CROPS AND LIVESTOCK, UNITED STATES, 1973 AND PROJECTIONS TO 1980

| | 1973 | | | 1980 Low exports | | | 1980 High exports | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crops or [2] livestock (million units) | Fuel per unit (gallons) | Total fuel (million gallons) | Crops or [4] livestock (million units) | Fuel per unit [3] (gallons) | Total fuel (million gallons) | Crops or [4] livestock (million units) | Fuel per unit [3] (gallons) | Total fuel (million gallons) |
| Acres of crops harvested: | | | | | | | | | |
| Corn, grain | 61.8 | 23.0 | 1,419 | 59.1 | 26.7 | 1,574 | 62.7 | 26.7 | 1,673 |
| Sorghum, grain | 15.9 | 13.3 | 211 | 15.9 | 13.0 | 207 | 16.5 | 12.2 | 201 |
| Other corn and sorghum | 12.3 | 16.7 | 206 | 10.8 | 16.6 | 180 | 10.8 | 16.7 | 181 |
| Wheat | 53.9 | 11.1 | 596 | 46.4 | 11.0 | 508 | 47.8 | 11.0 | 523 |
| Other grains | 29.6 | 12.7 | 375 | 28.2 | 12.8 | 360 | 28.5 | 12.8 | 366 |
| Soybeans | 56.4 | 22.8 | 1,288 | 56.5 | 22.7 | 1,283 | 62.1 | 22.5 | 1,398 |
| Peanuts | 1.5 | 29.3 | 44 | 1.5 | 27.4 | 40 | 1.5 | 27.4 | 40 |
| Cotton | 12.0 | 26.7 | 320 | 11.0 | 27.0 | 298 | 11.1 | 26.9 | 299 |
| Tobacco | .9 | 386.0 | 344 | 1.2 | 377.0 | 441 | 1.2 | 377.0 | 437 |
| Alfalfa hay | 27.5 | 13.4 | 368 | 25.8 | 13.1 | 338 | 25.8 | 13.1 | 339 |
| Other hay | 34.7 | 3.5 | 121 | 31.6 | 3.4 | 107 | 31.6 | 3.4 | 107 |
| Silage, grass | 2.1 | 36.4 | 77 | 2.5 | 35.7 | 89 | 2.5 | 35.7 | 89 |
| Selected pasture | 46.5 | 3.1 | 146 | 46.5 | 2.8 | 130 | 46.5 | 2.9 | 136 |
| Irish potatoes | 1.3 | 57.8 | 75 | 1.4 | 56.2 | 77 | 1.4 | 56.3 | 77 |
| Other vegetables | 3.3 | 36.0 | 119 | 3.6 | 33.9 | 123 | 3.6 | 33.9 | 123 |
| Fruit | 3.2 | 41.8 | 166 | 3.6 | 50.9 | 185 | 3.6 | 51.0 | 185 |
| Other crops | 8.6 | 44.1 | 380 | 8.1 | 43.1 | 349 | 8.1 | 43.1 | 349 |
| All crops and pasture | 371.5 | 16.8 | 6,255 | 353.7 | 17.8 | 6,289 | 365.3 | 17.9 | 6,523 |
| Number of livestock on farms: | | | | | | | | | |
| Milk cows | 11.7 | 38.1 | 444 | 10.2 | 37.2 | 380 | 10.2 | 37.2 | 380 |
| Other cows | 41.1 | 8.3 | 341 | 44.8 | 8.1 | 363 | 44.8 | 8.1 | 363 |
| Other cattle | 69.2 | 7.4 | 515. | 78.4 | 7.3 | 570 | 78.4 | 7.3 | 570 |
| Number of livestock sold: | | | | | | | | | |
| Hogs | 85.7 | 3.0 | 256 | 100.5 | 2.9 | 294 | 100.5 | 2.9 | 294 |
| Sheep and lambs | 12.7 | 2.1 | 27 | 8.0 | 2.1 | 17 | 8.0 | 2.1 | 17 |
| Broilers | 2,923.5 | (5) | 88 | 3,699.7 | (5) | 111 | 3,699.7 | (5) | 111 |
| Chickens | 250.3 | .2 | 43 | 324.8 | .2 | 55 | 324.8 | .2 | 55 |
| Turkeys | 132.2 | .2 | 24 | 154.6 | .2 | 28 | 154.6 | .2 | 28 |
| All livestock | | | 1,737 | | | 1,818 | | | 1,818 |
| Total crop and livestock | | | 7,992 | | | 8,1 7 | | | 8,341 |

[1] LP gas, butane and propane.

[2] Acres of crops harvested for most crops from USDA's "Crop Production, Annual Summary, CrPr 2-1 (74). Information for hay crops, silage, selected pasture, vegetables, fruit and other crops were projected from 1969. The number of livestock on farms are from USDA's "Livestock and Meat Statistics," SB No. 522 and the annual reports. The number of livestock sold are estimated from information in the following USDA reports: "Meat animals," "Livestock and Meat Statistics," "Poultry and Egg Situation," and "Chicken and Eggs."

[3] Estimates derived from projecting gasoline, diesel, and LP fuels (LP gas, butane, and propane) requirements per acre of crops and per head of livestock as determined via regression analysis of 1969 census data. Adjustments were made for greater use of fuel per acre and per unit of livestock on small farms, projected substitution among fuels, changes in irrigated acres, shift from corn pickers to corn combines, and for increased drying of corn, sorghum, and soybeans.

[4] Unpublished working material, Econ. Res. Serv., U.S. Dept. of Agr.

[5] Less than 0.05.

Note: Data computed from unrounded numbers.

TABLE 16.—PROJECTED GASOLINE, DIESEL AND LP FUEL[1] USED TO PRODUCE EXPORTED CROPS AND LIVESTOCK FOR 2 EXPORT ALTERNATIVES, UNITED STATES, 1980

| Item | Acre or livestock requirements for exports [2] | | Fuel requirements to produce exports | | | |
|---|---|---|---|---|---|---|
| | | | Quantity [3] | | Percent of total fuel [4] | |
| | Low exports (million units) | High exports (million units) | Low exports (million gallons) | High exports (million gallons) | Low exports | High exports |
| Acres of crops harvested: | | | | | | |
| Corn | 10.0 | 13.7 | 226.6 | 265.1 | 16.9 | 21.8 |
| Sorghum, grain | 2.7 | 3.9 | 34.4 | 47.5 | 16.7 | 23.7 |
| Other corn & sorghum | | | | | | |
| Wheat | 21.0 | 22.3 | 229.4 | 244.9 | 45.2 | 46.8 |
| Other grain | 2.8 | 3.1 | 35.6 | 39.7 | 9.9 | 10.9 |
| Soybean | 23.8 | 29.4 | 540.5 | 661.3 | 42.2 | 47.3 |
| Peanuts | .3 | .3 | 7.4 | .4 | 18.3 | 18.3 |
| Cotton | 3.8 | 3.8 | 101.1 | 102.4 | 34.0 | 34.2 |
| Tobacco | .3 | .3 | 110.1 | 110.1 | 25.0 | 25.0 |
| Alfalfa hay | | | | | | |
| Other hay | | | | | | |
| Silage grass | | | | | | |
| Selected pasture | | | | | | |
| Irish potatoes | ([5]) | ([5]) | .4 | .4 | .6 | .6 |
| Other vegetables | | | | | | |
| Fruit | | | | | | |
| Other crops | .5 | .5 | 20.7 | 20.7 | 5.9 | 5.9 |
| All crops and pasture | | | 1,306.2 | 1,592.5 | 21.4 | 24.5 |
| Number of livestock on farms: | | | | | | |
| Milk cows | .1 | .1 | 2.7 | 2.7 | .7 | .7 |
| Other cows | | | | | | |
| Other cattle | | | | | | |
| Number of livestock sold: | | | | | | |
| Hogs | | | | | | |
| Sheep and lambs | | | | | | |
| Broilers | 74.0 | 74.0 | 2.2 | 2.2 | 2.0 | 2.0 |
| Chickens | 2.3 | 2.3 | .4 | .4 | .7 | .7 |
| Turkeys | 1.2 | 1.2 | .2 | .2 | .8 | .8 |
| All livestock | | | 5.5 | 5.5 | .3 | .3 |
| Total crop and livestock | | | 1,317.2 | 1,603.5 | 16.7 | 19.2 |

[1] LP gas, butane and propane.
[2] Unpublished working material, Econ. Res. Serv., U.S. Dept. of Agr.
[3] Multiplied acres or livestock requirements to produce exports time fuel requirements per unit in table 3.
[4] Expressed fuel requirements for export as a percent of total fuel used in farm production in table 9.
[5] Less than 50,000.

Note: Data computed from unrounded numbers.

### *Demand for fuel to produce exports*

Fuel requirements for producing U.S. exports of both crops and livestock in 1980 will be between 1.4 billion and 1.6 billion gallons, 17–19 percent of the total fuel used in farming and 22–25 percent of the fuel used in crop production. Livestock exports will demand less than 1 percent of the total fuel used in livestock production (table 16).

More than a half-billion gallons of fuel will be used to grow soybeans for export and over a quarter billion gallons each for wheat and corn for export. Fuel used in the production of cotton and tobacco for export is also important as export production will consume a fourth to a third of the fuel for these crops.

For all crops in 1980, it was estimated that between 17.8 and 17.9 gallons of fuel would be needed per acre depending upon the level of exports. Thus, the level of exports has little effect on fuel use per acre.

Some have seriously questioned the advisability of importing petroleum products to produce agricultural goods for export. They see this as a cyclical venture achieving nothing.

In 1970, farmers were achieving a 3 for 1 return on each unit of energy input on corn production. For each Btu of energy input—including human energy—farmers received 3 Btu in the output of corn. When one compares only inputs based on petroleum products the return is about 5 to 1.

In comparing 1963 direct and indirect primary energy requirements of various economic activities agricultural products utilize much less energy than most manufactured products:

| Economic Activity | 10 Btu [1] / $TFD |
|---|---|
| Dairy farm products | 5. 7 |
| Poultry and eggs | 7. 5 |
| Meat animals and miscellaneous livestock products | 5. 7 |
| Cotton | 6. 1 |
| Food, feed grains, and grass seeds | 6. 9 |
| Tobacco | 5. 2 |
| Fruits and tree nuts | 3. 9 |
| Vegetables, sugar, and miscellaneous crops | 4. 1 |
| Oil seeds | 6. 3 |
| Forest, greenhouse, and nursery products | 4. 6 |
| Paper mills, except building paper | 17. 8 |
| Fertilizers | 18. 0 |
| Agricultural chemicals | 19. 9 |
| Cement, hydraulic | 42. 2 |
| Petroleum refining and related products | 19. 7 |
| Glass containers | 16. 3 |
| Blast furnaces and basic steel products | 26. 2 |
| Primary aluminum | 37. 8 |
| Farm machinery | 7. 7 |
| Computing and related machines | 2. 7 |
| Radio and TV receiving sets | 3. 8 |
| Electron tubes | 4. 8 |

[1] Btu per dollar of total final demand.

Source: Robert A. Harendeen, *The Energy Cost of Goods and Services*, Oak Ridge National Laboratory, Oak Ridge, Tenn., October 1973, Table 5.

It would appear from an energy standpoint that agricultural products should be among the last to be restricted from export.

The energy problem which has already resulted in higher fuel prices, however, can have a pronounced effect on the volume of U.S. agricultural exports.

With higher fuel prices, the ability of some countries to use foreign exchange reserves for the purchase of U.S. agricultural commodities is constrained. A number of countries importing U.S. agricultural commodities also import a large percentage of their energy. For example, Japan imports 100 percent of her oil and 89 percent of all forms of energy (table 17). Although these countries can reduce imports of energy through various conservation measures. compared with the United States, Japan and Italy, for example, have only about half the relative ability to conserve the use of oil. Thus an increased percentage of their foreign exchange reserves may go to the purchase

of energy and not for food. This is especially important for Japan, Italy, and the United Kingdom because the projected current account balance for 1974 with higher oil prices is greater than reserves for Italy and the United Kingdom and almost equal in Japan (table 18).

*Total demand for fuel*

Total gallons of fuel used in agricultural production in 1980 are expected to increase 1 to 4 percent above the 1973 level, depending on the level of exports. With low exports of agricultural products, fuel use in 1980 would rise about 1.4 percent above 1973 use to about 8.1 billion gallons (table 15). With high exports fuel use would increase about 4 percent to about 8.3 billion gallons. Fuel used in crop production has accounted for and would continue to account for about three-fourths of the total fuel requirements, and livestock for about one-fourth.

## Fuel Use Per Unit of Crops and Livestock

Relating 1969 Census of Agriculture fuel data to acres of crops and units of livestock with adjustments for known and anticipated changes in technology, fuel requirements per acre of crops and unit of livestock were estimated for 1973 and projected for 1980. (For methodology used see Appendix 1.) In 1973, an average of 16.8 gallons of refined petroleum fuel (gasoline, diesel, and LP gas) per acre was used for all crops. Fuel use varied from about 3 gallons per acre for pasture and hay other than alfalfa to over 50 gallons for Irish potatoes and fruit. Tobacco used nearly 390 gallons per acre, but most of this was for curing after harvest.

TABLE 17.—DEPENDENCE ON ENERGY IMPORTS AND RELATIVE ABILITY TO CONSERVE ON THE USE OF OIL IN 9 INDUSTRIAL COUNTRIES

| Country | Imports as a percent of domestic use [1] | | Relative ability to conserve on the use of oil (U.S.=100) [2] |
|---|---|---|---|
| | All forms of energy | Oil | |
| Japan | 89 | 100 | 43 |
| Italy | 85 | 94 | 50 |
| Belgium | 82 | 99 | 57 |
| France | 78 | 95 | 57 |
| Germany | 49 | 93 | 71 |
| United Kingdom | 47 | 98 | 64 |
| Netherlands | 36 | 93 | 80 |
| United States | 11 | 26 | 100 |
| Canada | [3] 10 | 2 | 80 |

[1] Based on 1971 experience.
[2] Based on an equation which reflects the fact that the greater the non-industrial use of energy is in an economy, the better able that economy is to cope with the oil situation without disrupting industrial production, and, the greater the use of oil as a source of energy (rather than coal, hydro-electric power, or other forms), the worse off an economy is. Since other factors which are unmeasured, or unmeasurable, need to be considered, the index is only a rough approximation of countries' abilities to cope with the "oil crisis."
[3] Net exporter of energy.

Source: Based on OECD data.

TABLE 18.—PROJECTED CURRENT ACCOUNT BALANCES FOR 1974, FOREIGN EXCHANGE RESERVES, AND RESERVES AS A RATIO OF PROJECTED BALANCES RESULTING FROM HIGHER OIL PRICES, OECD COUNTRIES

| Country [1] | Projected current account balance, 1974 [2] | | Reserves, (billions) Nov. 30, 1973 | Col. 2 as a ratio of col. 3 (percent) | Agricultural imports from the United States fiscal year 1973,[4] (millions) |
|---|---|---|---|---|---|
| | Without oil price increase (billions) | With higher oil prices [3] (billions) | | | |
| | (1) | (2) | (3) | (4) | (5) |
| Australia | −$0.1 | −$0.5 | $6.2 | 8 | $37 |
| Switzerland | .4 | −.6 | 7.2 | 8 | 133 |
| Spain | .2 | −1.0 | 6.7 | 15 | 400 |
| Canada | 0 | −1.0 | 5.7 | 18 | 657 |
| Germany | 1.0 | −6.0 | 34.1 | 18 | 903 |
| Netherlands | .8 | −1.2 | 6.2 | 19 | [5] 1,017 |
| Sweden | 1.0 | −.7 | 2.4 | 29 | 59 |
| Belgium-Luxembourg | .5 | −1.5 | 5.0 | 30 | 196 |
| Austria | −.6 | −1.0 | 2.9 | 34 | 17 |
| Ireland | −.2 | −.4 | 1.1 | 36 | 42 |
| Norway | −.8 | −1.2 | 1.6 | 75 | 72 |
| France | −.8 | −6.8 | 8.6 | 79 | 355 |
| Japan | −.5 | −11.5 | 13.2 | 87 | 2,311 |
| Italy | −1.4 | −6.4 | 6.1 | 105 | 509 |
| United Kingdom | −3.0 | −8.0 | 6.6 | 121 | 550 |
| Denmark | −.6 | −1.6 | 1.2 | 133 | 139 |
| Finland | −.6 | −1.2 | .6 | 200 | 19 |
| United States | 5.0 | −6.0 | (6) | (6) | |

[1] Listed by relative pressure on foreign exchange reserves (re col. 4).
[2] Minus denotes deficit. The current account includes international transactions in good services, and unilateral (both government and private) transfers. Balances without oil price increase are OECD projections; balances reflecting higher prices of oil are ERS estimates.
[3] Assumes no change in 1974 from volume imported in 1973.
[4] Adjusted for transshipments through Canada but not through the Netherlands and Belgium data not yet available for the latter adjustment.
[5] Includes shipments destined to Germany, United Kingdom, and other nations. In fiscal year 1973 transshipments equalled nearly 30 percent of total agricultural imports from the United States.
[6] Not applicable; U.S. dollar is international medium of exchange.

The top three crops in terms of acres grown, corn for grain, soybeans, and wheat, accounted for over half of all fuel used in crop production. The fuel needs per acre for growing these crops were 23 gallons for corn and soybeans, and 11 gallons for wheat.

## Substitution Among Fuels

The substitution of diesel for gasoline in farming will continue. In 1980 diesel fuel use in agriculture production is expected to be up from 2.2 billion gallons to between 2.8 billion and 2.9 billion gallons—an increase of 27 to 32 percent (table 19). Gasoline use is expected to be down from 4.4 billion gallons to between 3.9 billion and 4 billion gallons—a decrease of 9 to 11 percent.

In 1973 gasoline accounted for about 55 percent of the volume of gasoline, diesel, and LP gas. Diesel fuel accounted for 28 percent. In 1980 it is projected that gasoline will account for about 48 percent of the total. LP gas will still account for about 17 percent of the total. Less use of LP fuels in tractors will be offset by increased use in drying crops. With the substitution of diesel fuel for gasoline, fewer gallons of fuel are needed. This need for less fuel is partly offset by additional fuel needed for irrigating more acres in 1980.

## Fuel Usage by Major Farm Machines

In 1970, power machines consumed 70 percent of all liquid petroleum fuel used on farms as farmers have substituted capital for labor at an astounding rate (table 20). In 1940, they purchased $625 million worth of motor vehicles and other machinery and equipment and used 20.5 billion hours of labor. Machinery purchases per hour of labor averaged 3 cents. In 1973, farmers purchased over $7.4 billion of farm equipment and machinery and used about 6.5 billion hours of labor, so machinery expenditures per hour of labor averaged $1.14 (table 21). The stock of major machines on farms rose rapidly and by 1957 there was an average of one tractor per farm. In 1973 there were 1.5 tractors per farm (table 22).

TABLE 19.—GASOLINE, DIESEL AND LP FUEL[1] USED IN FARM PRODUCTION, UNITED STATES, 1973 AND PROJECTIONS FOR 1980

| Item | 1973 | | 1980 projections | | | |
|---|---|---|---|---|---|---|
| | | | Low exports | | High exports | |
| | Billion gallons | Percent | Billion gallons | Percent | Billion gallons | Percent |
| All fuel Used for: | | | | | | |
| Crops | 6.3 | 79 | 6.3 | 78 | 6.5 | 78 |
| Livestock | 1.7 | 21 | 1.8 | 22 | 1.8 | 22 |
| Total | 8.0 | 100 | 8.1 | 100 | 8.3 | 100 |
| Fuel by Types: | | | | | | |
| Gasoline | 4.4 | 55 | 3.9 | 48 | 4.0 | 48 |
| Diesel | 2.2 | 28 | 2.8 | 35 | 2.9 | 35 |
| LP Fuels | 1.4 | 17 | 1.4 | 17 | 1.4 | 17 |
| Total | 8.0 | 100 | 8.1 | 100 | 8.3 | 100 |

[1] LP gas, butane, and propane

TABLE 20.—FARM CONSUMPTION OF LIQUID PETROLEUM FUEL BY USE, 48 STATES, SPECIFIED YEARS[1]

| | Motor fuel consumed by— | | | | | | | All uses | |
|---|---|---|---|---|---|---|---|---|---|
| | Tractors (million gallons) | Auto-mobiles (million gallons) | Motor-trucks (million gallons) | Other power units (million gallons) | All power machines (million gallons) | Other fuels[2] (million gallons) | House-hold use (million gallons) | Total (million gallons) | Average per farm[3] (gallons) |
| 1920 | 271 | 514 | 53 | ([4]) | ([4]) | ([4]) | ([4]) | ([4]) | ([4]) |
| 1930 | 748 | 1,388 | 341 | ([4]) | ([4]) | ([4]) | ([4]) | ([4]) | ([4]) |
| 1940 | 1,399 | 1,538 | 397 | ([4]) | ([4]) | ([4]) | ([4]) | ([4]) | ([4]) |
| 1947 | 2,820 | 1,695 | 845 | 278 | 5,638 | ([5]) | 1,459 | 7,097 | 1,209 |
| 1953 | 3,271 | 2,073 | 1,069 | 362 | 6,775 | 456 | 1,577 | 8,808 | 1,767 |
| 1959 | 3,370 | 1,639 | 1,064 | 379 | 6,452 | 421 | 1,737 | 8,610 | 2,101 |
| 1970[6] | 3,342 | 1,637 | 1,420 | 446 | 6,845 | 810 | 1,947 | 9,602 | 3,250 |

[1] Does not include motor oil or other lubricants, natural and utility gas.
[2] Used for drying crops; brooding, killing weeds; heating water, buildings, and orchards; and miscellaneous other uses.
[3] Based on "Number of Farms, 1910–1959, Land in Farms, 1960–1959, by States." U.S. Dept. Agr. Statis, Bul. 316. June 1972.
[4] Not available.
[5] Included in household use.
[6] Based on a 1970 ERS/SRS Survey on Petroleum Fuel Used in Farm Production, unpublished data

TABLE 21.—GROSS CAPITAL EXPENDITURES FOR FARM MOTOR VEHICLES, OTHER MACHINERY, AND EQUIPMENT AND HOURS OF LABOR USED IN FARMWORK, SELECTED YEARS 1940–73

| Years | Expenditures for motor vehicles, machinery, and equipment (millions) | Hours of farm work (million hours) | Equipment expenditures per hour of labor |
|---|---|---|---|
| 1940 | $625 | 20,472 | $0.03 |
| 1945 | 1,198 | 18,838 | .06 |
| 1950 | 3,152 | 15,137 | .21 |
| 1955 | 2,760 | 12,808 | .22 |
| 1960 | 2,802 | 9,795 | .29 |
| 1965 | 4,179 | 7,775 | .54 |
| 1970 | 4,918 | 6,522 | .75 |
| 1971 | 4,873 | 6,398 | .76 |
| 1972 | 5,583 | 6,172 | .90 |
| 1973 [1] | 7,430 | 6,508 | 1.14 |

[1] Preliminary.

TABLE 22.—FARM NUMBERS, MOTOR VEHICLES AND SPECIFIED MACHINES ON FARMS, 48 STATES, JAN. 1, 1940–73[1]

| Year | Number of farms (thousands) | Acres per farm | Tractors (exclusive of steam and garden) Number [2] (thousands) | Tractors Horsepower (millions) | Motortrucks [2] (thousands) | Automobiles (thousands) | Grain combines (thousands) | Cornpickers and picker-shellers (thousands) | Farms with milking machines (thousands) | Pickup balers (thousands) | Field forage harvesters (thousands) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1940 | 6,350 | 167 | [2] 1,567 | 35 | [4] 1,047 | [4] 4,144 | 190 | 110 | 175 | | |
| 1941 | 6,293 | | 1,665 | 39 | 1,095 | | 225 | 120 | 210 | | |
| 1942 | 6,202 | | 1,860 | 47 | 1,160 | | 275 | 130 | 255 | 25 | |
| 1943 | 6,089 | | 2,055 | 53 | 1,280 | | 320 | 138 | 275 | 31 | |
| 1944 | 6,008 | | 2,160 | 56 | 1,385 | | 345 | 146 | 300 | 34 | |
| 1945 | 5,967 | 191 | [2] 2,354 | 61 | [4] 1,490 | 4,148 | [4] 375 | 168 | [4] 365 | 42 | 20 |
| 1946 | 5,926 | | 2,480 | 64 | 1,550 | | 420 | 203 | 440 | 54 | 25 |
| 1947 | 5,871 | | 2,613 | 69 | 1,700 | | 465 | 236 | 525 | 65 | 30 |
| 1948 | 5,803 | | 2,821 | 77 | 1,900 | | 535 | 299 | 575 | 90 | 45 |
| 1949 | 5,722 | | 3,123 | 85 | 2,065 | | 620 | 372 | 610 | 135 | 60 |
| 1950 | 5,648 | 213 | [4] 3,394 | 93 | [4] 2,207 | 4,100 | [4] 714 | [4] 456 | [4] 636 | [4] 196 | 81 |
| 1951 | 5,428 | 222 | 3,678 | 101 | 2,325 | | 810 | 522 | 655 | 240 | 102 |
| 1952 | 5,198 | 232 | 3,907 | 108 | 2,430 | | 887 | 588 | 675 | 298 | 124 |
| 1953 | 4,984 | 242 | 4,100 | 115 | 2,535 | | 930 | 630 | 690 | 345 | 148 |
| 1954 | 4,798 | 251 | 4,243 | 121 | 2,610 | | 965 | 660 | 705 | 395 | 175 |
| 1955 | 4,654 | 258 | [4] 4,345 | 126 | 2,675 | 4,140 | [4] 980 | [4] 688 | [4] 712 | [4] 448 | [4] 202 |
| 1956 | 4,514 | 265 | 4,480 | 134 | 2,707 | | 1,005 | 715 | | 505 | 220 |
| 1957 | 4,372 | 272 | 4,570 | 139 | 2,745 | | 1,015 | 740 | | 560 | 240 |
| 1958 | 4,233 | 280 | 4,620 | 144 | 2,775 | | 1,030 | 755 | | 600 | 258 |
| 1959 | 4,105 | 288 | 4,673 | 150 | 2,800 | | 1,045 | 775 | | 645 | 270 |
| 1960 | 3,963 | 297 | [4] 4,688 | 153 | [4] 2,834 | [3] 3,636 | [4] 1,042 | [4] 792 | [4] 666 | [4] 680 | [4] 291 |
| 1961 | 3,825 | 305 | 4,743 | 158 | 2,850 | | 980 | 740 | | 685 | 291 |
| 1962 | 3,692 | 314 | 4,763 | 162 | 2,885 | | 960 | 730 | | 703 | 300 |
| 1963 | 3,572 | 322 | 4,778 | 167 | 2,925 | | 940 | 720 | | 718 | 307 |
| 1964 | 3,457 | 332 | 4,786 | 172 | 2,970 | | 920 | 705 | | 734 | 312 |
| 1965 | 3,356 | 340 | [4] 4,787 | 176 | [4] 3,030 | [3] 3,593 | [4] 910 | [4] 690 | [4] 500 | [4] 751 | [4] 316 |
| 1966 | 3,257 | 348 | 4,783 | 182 | 3,017 | | 888 | 686 | | 752 | 316 |
| 1967 | 3,162 | 355 | 4,786 | 189 | 3,009 | | 867 | 680 | | 748 | 319 |
| 1968 | 3,071 | 363 | 4,766 | 195 | 3,016 | | 847 | 673 | | 739 | 321 |
| 1969 | 2,999 | 369 | 4,712 | 199 | 3,004 | | 820 | 657 | | 725 | 314 |
| 1970 | 2,954 | 373 | [4] 4,619 | 203 | [4] 2,984 | [3] 2,688 | 790 | [4] 635 | | [4] 708 | 304 |
| 1971 | 2,909 | 377 | 4,562 | 206 | 2,969 | | 760 | 618 | | 687 | 300 |
| 1972 | 2,870 | 381 | 4,469 | 209 | 2,943 | | 725 | 612 | | 663 | 298 |
| 1973 [5] | 2,844 | 383 | 4,387 | 212 | 2,915 | | 703 | 607 | | 642 | 294 |

[1] Current Industrial Reports of the Bureau of the Census (formerly Facts for Industry), annual registrations of motor vehicles, results of enumerative and mailed questionnaire surveys, changes in gross farm income, and estimated discard rates, were used in developing estimates for years and machines not covered by census reports. Data as of Jan. 1.

[2] Annual data for 1910–49 in 1964 issue of this publication, except for automobiles which are not estimated for intercensal years after 1940. Includes Alaska and Hawaii in 1960 and later years.

[3] Includes cornheads for combines.

[4] Census for Agriculture, census dates: Apr. 1, 1950: November 1954, 1959, 1964, and 1969.

[5] Preliminary.

Over time, there has been a substantial shift in the type of fuel used in farming. Diesel fuel use has been increasing sharply—more than doubling since 1964. Increased numbers of diesel powered tractors and combines have led to this shift in relative quantities of fuel used by type. While total tractor numbers on farms have been declining since 1964, diesel tractor numbers have been increasing. Currently 80 percent of wheel tractor purchases are diesel and the proportion is expected to increase to about 85 percent by 1975. Because of the large inventory of gasoline tractors, the current proportion of tractor stocks that are diesel is about 40 percent. By 1980 we expect diesel tractors will approximate 57 percent of all farm tractors.

The shift to diesel powered combines has trailed the adoption of diesel tractors. However, current statistics indicate the shift to diesel combines will occur more rapidly. In 1971, only 22 percent of the combines sold were diesel. By 1972, the proportion that were diesel increased sharply to 35 percent of sales and during 1973 diesel combines accounted for 50 percent of all sales [16, 28].

Increased size of tractors and combines have accompanied the shift to diesel. In 1955 and 1973, tractor numbers were nearly identical, but total horsepower increased nearly 70 percent—126 million in 1955 as compared with 212 million in 1973. Thus, increasing farm demand for diesel fuel results both from more diesel units and larger power units.

Economics play an important role in the shift to diesel fuel use in farming. Diesel powered wheel tractors have regularly had higher price tags than similar size gasoline units. In 1973, list prices for 70 h.p. tractors averaged about $8,240 for diesel and $7,140 for gasoline, a difference of $830 or 11 percent [41]. On the other hand, diesel fuel contains 10.5 percent more Btu per gallon than gasoline. And the higher compression diesel engine operates more efficiently, so the same amount of work can be done with 27 percent less fuel. In 1970, diesel wheel tractors used an average of 1,068 gallons of fuel per year (table 23). Similar size gasoline units would have averaged 1,356 gallons of gasoline. At 1973 farm prices of $0.227 per gallon of diesel and $0.297 for gasoline, the fuel bills would have been $242.44 per diesel unit and $402.73 per gasoline unit or $160.29 less for diesel. When discounted at 8 percent interest, the $830 greater purchase price would be recovered in 7.2 years. Furthermore, diesel units usually require less maintenance and have higher resale values so the advantage over gasoline units is even greater than expressed here.

Diesel powered machines generally are larger than their gasoline counterparts. Being larger and newer they are used much more extensively as measured by fuel use. In 1970, diesel wheel tractors used 90 percent more fuel per unit than did gasoline units. Diesel crawler tractors used 75 percent more, trucks 9 percent more, and combines 9 percent more (table 23).

TABLE 23.—MAJOR FARM POWER UNITS: NUMBERS AND GALLONS OF FUEL USED PER MACHINE, BY REGION, 1970[1]

| Region | Wheel tractors | | Crawler tractors | | Trucks | | Combines[2] | | Automobiles | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Gallons per unit | Number | Gallons per unit | Number | Gallons per unit | Number | Gallons per unit | Number | Gallons per unit |
| Gasoline powered: | | | | | | | | | | |
| Northeast | 276, 999 | 505 | 10, 757 | 315 | 186, 925 | 470 | 15, 409 | 300 | 189, 013 | 538 |
| Lake States | 495, 991 | 553 | 8, 522 | 336 | 278, 431 | 349 | 49, 459 | 415 | 340, 095 | 573 |
| Corn Belt | 880, 096 | 651 | 10, 309 | 388 | 562, 816 | 447 | 138, 127 | 516 | 665, 444 | 614 |
| Northern Plains | 316, 422 | 673 | 5, 262 | 360 | 380, 195 | 386 | 101, 917 | 519 | 298, 109 | 643 |
| Appalachian | 372, 866 | 388 | 4, 168 | 315 | 361, 936 | 425 | 20, 925 | 453 | 381, 351 | 537 |
| Southeast | 112, 145 | 445 | 3, 178 | 489 | 207, 499 | 576 | 11, 880 | 503 | 178, 676 | 603 |
| Delta States | 73, 976 | 539 | 863 | 508 | 166, 436 | 645 | 19, 741 | 959 | 124, 253 | 662 |
| Southern Plains | 128, 556 | 585 | 1, 446 | 799 | 310, 866 | 672 | 30, 414 | 624 | 227, 670 | 694 |
| Mountain | 113, 233 | 547 | 2, 886 | 756 | 227, 449 | 454 | 28, 363 | 559 | 131, 063 | 661 |
| Pacific | 134, 568 | 508 | 4, 855 | 1, 023 | 207, 014 | 570 | 13, 700 | 817 | 134, 552 | 679 |
| United States | 2, 904, 852 | 565 | 52, 146 | 455 | 2, 889, 567 | 483 | 429, 935 | 535 | 2, 670, 226 | 610 |
| Diesel powered: | | | | | | | | | | |
| Northeast | 68, 779 | 593 | 7, 132 | 269 | 2, 072 | 357 | 905 | 445 | 1, 008 | 511 |
| Lake States | 125, 825 | 871 | 7, 967 | 405 | 445 | 338 | 1, 642 | 411 | --- | --- |
| Corn Belt | 250, 655 | 1, 018 | 14, 058 | 387 | 12, 919 | 518 | 4, 840 | 485 | 1, 083 | 570 |
| Northern Plains | 206, 421 | 1, 296 | 8, 401 | 388 | 2, 902 | 374 | 3, 389 | 513 | --- | --- |
| Appalachian | 125, 429 | 553 | 7, 387 | 345 | 2, 675 | 454 | 1, 293 | 441 | 943 | 563 |
| Southeast | 124, 337 | 789 | 5, 499 | 465 | 3, 863 | 483 | 1, 723 | 521 | 574 | 573 |
| Delta States | 128, 300 | 1, 499 | 5, 960 | 651 | 4, 036 | 608 | 596 | 868 | 4, 417 | 613 |
| Southern Plains | 154, 694 | 1, 375 | 7, 785 | 764 | 3, 344 | 673 | 1, 147 | 643 | 2, 306 | 695 |
| Mountain | 95, 027 | 1, 231 | 22, 237 | 828 | 4, 345 | 555 | 1, 904 | 606 | 1, 158 | 681 |
| Pacific | 44, 218 | 1, 142 | 59, 101 | 1, 162 | 9, 313 | 562 | 3, 242 | 915 | 1, 066 | 680 |
| United States | 1, 323, 685 | 1, 068 | 145, 527 | 796 | 45, 914 | 525 | 20, 681 | 583 | 12, 555 | 622 |

[1] Numbers of units are from the 1969 Census of Agriculture. Gallons of fuel used per machine are from the SRS–ERS survey of petroleum fuel used in farming, 1970.

[2] Self-propelled.

TABLE 24.—AIRCRAFT USE IN AGRICULTURE: NUMBER USED, HOURS FLOWN AND ACRES TREATED, SELECTED YEARS, 1955–71 [1]

| Year | Aircraft used | Flight hours (thousands) | Acres treated (thousands) |
|---|---|---|---|
| 1955 | 5,200 | 852 | 50,157 |
| 1956 | 5,070 | 802 | 51,938 |
| 1957 | 5,100 | 866 | 61,255 |
| 1958 | (2) | (2) | (2) |
| 1959 | 4,960 | 880 | 50,891 |
| 1960 | 5,130 | 889 | 51,978 |
| 1961 | 4,814 | 855 | 54,978 |
| 1962 | 5,075 | 949 | 64,828 |
| 1970 | 5,802 | 1,396 | [3]90,750 |
| 1971 | 5,530 | 1,398 | [3]90,880 |

[1] From FAA, Aircraft in Agriculture, 1962 and unpublished FAA data for 1970 and 1971.
[2] Not available.
[3] Estimated in USDA, ERS.

TABLE 25.—IRRIGATION OF SELECTED CROPS, UNITED STATES, 1969 AND 1980

[In percent]

| Crops [1] | 1969 [2] | 1980 [3] Low exports | 1980 [3] High exports |
|---|---|---|---|
| Corn, grain | 6.4 | 6.1 | 6.0 |
| Sorghum, grain | 26.9 | 26.8 | 23.3 |
| Wheat | 4.6 | 6.0 | 6.1 |
| Other grain | 6.5 | 12.9 | 13.4 |
| Soybeans | 1.8 | 2.2 | 1.7 |
| Peanuts | 12.3 | 10.6 | 10.7 |
| Cotton | 28.1 | 38.5 | 38.4 |
| Alfalfa | 15.4 | 15.9 | 16.0 |
| Irish potatoes | 54.8 | 51.6 | 51.7 |
| Other vegetables | 33.3 | 45.9 | 46.1 |
| Fruit | 57.4 | 60.4 | 60.9 |

[1] Selected crops.
[2] U.S. Census of Agriculture.
[3] Unpublished working materials, Econ. Res. Serv., U.S. Dept. of Agr.

Often overlooked as a major power input in farming are "tractors in the sky"—the aerial crop dusters. In 1971, some 5,530 aircraft flew 1.4 million hours and treated about 91 million acres of farmland (table 24). These aircraft used 38.5 million gallons of gasoline and about 325,000 gallons of jet fuel. Preliminary estimates for 1972 indicate over 100 million acres of farmland were treated.

There is some irrigation on nearly all farm crops. Fruits and vegetables are most often irrigated. In 1969 over half the fruit and Irish potatoes were irrigated and a third of the other vegetables (table 25). Also, about a fourth of the cotton and sorghum were irrigated in 1969. Corn, wheat, other grains, and soybeans are crops least often irrigated.

By 1980 the percentage of acres irrigated may be up slightly. However, irrigated cotton acres are estimated to increase to 38 percent from 28 percent in 1969.

As more acres are irrigated, additional fuel will be used for each acre, chiefly to power pumps and harvest larger yields. Additional fuel requirements for irrigated acres are the greatest for grain sorghum. On

the average, nearly 3 times more fuel was used for growing irrigated than nonirrigated sorghum. More than twice as much fuel was used on the irrigated alfalfa, soybeans, and wheat; and about a half again as much on corn, cotton, and fruit.

Irrigated cropland for 1980 includes estimates of private development and all public irrigation projects authorized and funded as of 1972. The private development of irrigated cropland is projected on the basis of historical trends and constraints imposed by depleting groundwater and land suitable for irrigation.

The new emphasis on energy development in the Rocky Mountains and the Northern Great Plains affects both land and water. While some agricultural land will be removed from production, the demand for water is of greater concern. Estimates are that energy development will require as much water as would irrigate 150,000 to 300,000 acres for intensive crop production annually (appendix 2).

*1980 Fuel Use by Major Farm Machines*

The major on-farm use for petroleum fuel will likely continue to be in tractors, self-propelled combines, automobiles, and trucks. There also will continue to be major shifts in the composition of all fuels used on farms as diesel-powered farm machines replace their gasoline—and LP-powered counterparts.

*Tractors.*—Estimation of 1980 fuel usage by farm tractors involves determining the 1980 stock of gasoline and diesel-powered tractors on farms. Table 26 shows the increasing dominance of agricultural tractor sales by diesel-powered units. A prime reason for the growing numbers of tractors and other farm machines powered by diesel engines is their efficiency. By 1979, 84 percent of all agricultural tractors sold that year may be diesel-powered and there may be no more LP units sold.

An estimated 79 percent of wheel tractors on farms January 1, 1970, were powered by gasoline or LPG, the rest were diesel. An age distribution was estimated for each type of machine by combining unit sales or shipments of farm wheel tractors and estimates of their discard rates for years subsequent to their manufacture. Most of the diesel wheel tractors on farms January 1, 1970, were relatively new, having been manufactured since 1964 (table 27). Conversely, three-fourths of the gasoline tractors on farms were 12 years or older.

By 1980, wheel tractor stocks will have declined 20 percent from 1970 to 3.5 million units. Over half the units will be diesel powered. Nearly two-thirds of the diesel tractors will be less than 10 years of age, compared with less than a third of the gasoline and LP tractors.

Relating tractor stocks by acres per farm with 1970 fuel use data indicates that 3 billion gallons of fuel will be required for wheel tractors in 1980 (table 28). Of this, 71 percent will be diesel.

*Combines.*—The widespread conversion from pull-type to self-propelled combines which began in the 1960's has continued into the 1970's. Sales of self-propelled units now far exceed those of pull-type units. In addition, a transition from gasoline to diesel-powered units has occurred—similar to but more accelerated than the trend for wheel tractors. In the past 10 years, diesel self-propelled combine

sales went from zero to two-thirds of the total (table 29). Industry sources estimate that by 1976 the switch to diesel power will have stabilized at 90 percent of all sales (figure 4).

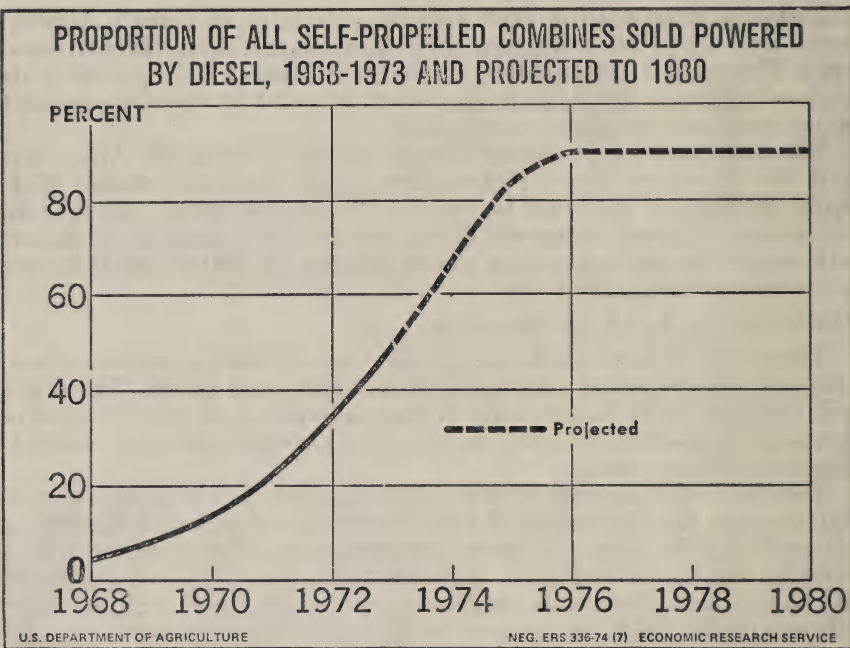


FIGURE 4

TABLE 26.—UNIT RETAIL SALES OF TWO WHEEL DRIVE AGRICULTURAL TRACTORS, UNITED STATES, BY FUEL TYPE, 1970–73 AND PROJECTIONS FOR 1974–79

| Year | Unit retail sales: Gasoline and LP | Unit retail sales: Diesel | Unit retail sales: Total | Relative proportions (percent): Gasoline and LP of total | Relative proportions (percent): Diesel of total |
|---|---|---|---|---|---|
| 1970 | 53,700 | 123,000 | 176,700 | 30 | 70 |
| 1971 | 42,891 | 129,709 | 172,600 | 25 | 75 |
| 1972 | 30,366 | 126,821 | 157,187 | 19 | 81 |
| 1973 | 38,322 | 154,552 | 192,874 | 20 | 80 |
| 1974 estimated | 35,904 | 151,096 | 187,000 | 19 | 81 |
| 1975 estimated | 29,600 | 130,400 | 160,000 | 18 | 82 |
| 1976 estimated | 23,852 | 110,148 | 134,000 | 18 | 82 |
| 1977 estimated | 22,230 | 107,770 | 130,000 | 17 | 83 |
| 1978 estimated | 20,664 | 105,336 | 126,000 | 16 | 84 |
| 1979 estimated | 20,410 | 109,590 | 130,000 | 16 | 84 |

Source: FIEI retail sales reports and ERS estimates.

TABLE 27.—NUMBER AND PROPORTIONS OF WHEEL TRACTORS ON FARMS, BY FUEL TYPE AND AGE, JAN. 1, 1970, WITH PROJECTIONS FOR JAN. 1, 1980

1970

| Item | Gasoline and LP: Number | Gasoline and LP: Percent of total | Diesel: Number | Diesel: Percent of total | Total: Number | Total: Percent of total |
|---|---|---|---|---|---|---|
| Number on farms Jan. 1, 1970 | 3,501,900 | 79.3 | 914,100 | 20.7 | 4,416,000 | 100.0 |
| Age: | | | | | | |
| 6 years or less | 416,650 | 11.9 | 559,980 | 61.3 | 976,630 | 22.1 |
| 7 to 11 years | 430,464 | 12.3 | 286,991 | 31.4 | 717,405 | 16.3 |
| 12 years or more | 2,654,786 | 75.8 | 67,179 | 7.3 | 2,721,965 | 61.6 |

TABLE 27.—NUMBER AND PROPORTIONS OF WHEEL TRACTORS ON FARMS, BY FUEL TYPE AND AGE, JAN. 1, 1970, WITH PROJECTIONS FOR JAN. 1, 1980—Continued

1980

| | Gasoline and LP | | Diesel | | Total | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent |
| Number on farms Jan. 1, 1980 | 1,517,765 | 43.0 | 2,014,235 | 57.0 | 3,532,000 | 100.0 |
| Manufactured: | | | | | | |
| 1970–79 | 307,993 | 20.2 | 1,214,994 | 60.3 | 1,522,987 | 43.1 |
| 1964–69 | 363,602 | 24.0 | 499,055 | 24.8 | 862,657 | 24.4 |
| 1959–63 | 321,103 | 21.2 | 217,350 | 10.8 | 538,452 | 15.3 |
| 1958 or before | 525,068 | 34.5 | 82,836 | 4.1 | 607,904 | 17.2 |

Sources: 1969 Census of Agriculture and ERS estimates.

TABLE 28.—ESTIMATED JAN. 1, 1980, STOCKS OF WHEEL TRACTORS ON FARMS, BY FARM SIZE AND FUEL TYPE AND FUEL CONSUMPTION PER UNIT AND TOTAL

| Item | Size of farm (acres) | | | | | |
|---|---|---|---|---|---|---|
| | 1–99 | 100–179 | 180–259 | 260–499 | 500 or more | Total or average |
| | Number | | | | | |
| Tractors on farms Jan. 1, 1980: | | | | | | |
| Gasoline and LP gas | 423,912 | 324,043 | 206,112 | 307,196 | 256,502 | 1,517,765 |
| Diesel | 181,281 | 201,424 | 221,566 | 503,559 | 906,405 | 2,014,235 |
| Total | 605,193 | 525,467 | 427,678 | 810,755 | 1,162,907 | 3,532,000 |
| | Gallons [1] | | | | | |
| Fuel consumed per tractor: | | | | | | |
| Gasoline and LP gas | 336 | 482 | 607 | 739 | 894 | 580 |
| Diesel fuel | 413 | 478 | 616 | 884 | 1,547 | 1,068 |
| | Millions gallons | | | | | |
| Total consumption: | | | | | | |
| Gasoline and LP gas | 142 | 156 | 125 | 227 | 230 | 880 |
| Diesel | 75 | 96 | 137 | 445 | 1,402 | 2,155 |
| Total | 217 | 252 | 262 | 672 | 1,632 | 3,035 |

[1] 1970 ERS/SRS petroleum fuel use survey.

Source: ERS estimates.

TABLE 29.—RETAIL SALES OF SELF-PROPELLED COMBINES, BY TYPE OF ENGINE, 1965–73, WITH PROJECTIONS THROUGH 1980

| Year of sale | Units sold | Gasoline engine [1] | | Diesel engine | |
|---|---|---|---|---|---|
| | | Percent [2] | Number | Percent [1] | Number |
| 1965 | 38,000 | 98.7 | 37,506 | 1.3 | 494 |
| 1966 | 40,000 | 97.5 | 39,000 | 2.5 | 1,000 |
| 1967 | 41,000 | 96.2 | 39,442 | 3.8 | 1,558 |
| 1968 | 33,000 | 95.0 | 31,350 | 5.0 | 1,650 |
| 1969 | 27,000 | 91.6 | 24,732 | 8.4 | 2,268 |
| 1970 | 27,000 | 86.0 | 23,220 | 14.0 | 3,780 |
| 1971 | 27,000 | 77.0 | 20,790 | 23.0 | 6,210 |
| 1972 | 28,000 | 64.8 | 18,144 | 35.2 | 9,856 |
| 1973 | 35,000 | 50.5 | 17,675 | 49.5 | 17,325 |
| 1974 (est.) | 33,000 | 33.0 | 10,890 | 67.0 | 22,110 |
| 1975 (est.) | 31,000 | 16.0 | 4,960 | 84.0 | 26,040 |
| 1976 (est.) | 29,000 | 10.0 | 2,900 | 90.0 | 26,100 |
| 1977 (est.) | 27,000 | 10.0 | 2,700 | 90.0 | 24,300 |
| 1978 (est.) | 29,000 | 10.0 | 2,900 | 90.0 | 26,100 |
| 1979 (est.) | 31,000 | 10.0 | 3,100 | 90.0 | 27,900 |

[1] Includes small numbers of LP gas engines.
[2] Percentages for 1965–1970 and 1974–1979 estimated in ERS. Percentages for 1971–1973 from Farm and Industrial Equipment Institute.

Sources: Farm and Industrial Equipment Institute statistics on retail unit sales, Department of Commerce's Current Industrial Reports MA-35(A), and ERS estimates.

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By 1980, self-propelled combine stocks will total 534,000 and 30 percent will be diesel powered (table 30). Fuel requirements projected for combining each of 11 major crops in 1980 total 315 million gallons (table 31). For each commodity, except for rice and flax, it was assumed that 60 percent of the crop would be harvested by diesel combines and 40 percent by gasoline units. For rice and flax, the assumed diesel-gasoline compositions were 95–5 and 25–75, respectively. Of the total projected gallonage, diesel fuel represents approximately 53 percent.

Two other important uses of fuel related to combining major commodities are (1) hauling harvested crops from farms to elevators or assembly points, and (2) moving custom combines between areas as the harvest season proceeds. Fuel required to haul the projected production of 11 major crops totaled 116 million gallons of gasoline. This assumed:

(1) All trucks hauling the crops are gasoline-powered, with an average fuel consumption of 5 miles per gallon.

(2) The round trip distance between a farm and elevator or assembly point is 30 miles.

(3) The average payload hauled is 18,000 pounds.

(4) 65 percent of the corn harvested for grain will be moved off the farm, while 35 percent will remain.

A 1971 ERS survey of interstate custom combining crews in the Great Plains, to be published shortly, revealed an estimated 7,600 custom machines in operation, each harvesting more than 1,850 acres per year. Custom combining operations have become increasingly favored among farmers because the crop can be harvested promptly when ripe—reducing loss due to weather. Also, self-propelled machines have become increasingly expensive. As a result, ownership of a combine requires that the individual harvest large acreages to fully utilize the machine and spread fixed costs. It is expected that the scope of custom combining will continue to increase in the future.

TABLE 30.—ESTIMATED STOCKS OF SELF-PROPELLED COMBINES ON FARMS, 1980, BY FUEL TYPE AND AGE, AND PROPORTIONS OF TOTAL COMBINING DONE BY EACH GROUP

| Age | Number of units on farms | | | Proportion of combining done by | | |
|---|---|---|---|---|---|---|
| | Gasoline [1] | Diesel | Total | Gasoline | Diesel | Total |
| 6 years or less | 26,729 | 126,041 | 152,770 | 17.0 | 83.0 | 66.6 |
| 7–11 years | 96,209 | 31,296 | 127,505 | 75.0 | 25.0 | 16.7 |
| 12 years or more | 250,639 | 3,386 | 254,025 | 99.0 | 1.0 | 16.7 |
| Total | 373,577 | 160,723 | 534,300 | 40.0 | 60.0 | 100.0 |

[1] Includes small numbers of LP gas units.

TABLE 31.—PROJECTED 1980 ACREAGES OF COMBINED CROPS, FUEL USE COEFFICIENTS AND TOTAL ESTIMATED GALLONAGE, BY TYPE OF FUEL

| Crop | Projected 1980 harvested acreage [1] | Projected acreage harvested by combines | | Estimated per acre fuel use (gallons) | | Total estimated fuel use (thousands of gallons) | | |
|---|---|---|---|---|---|---|---|---|
| | | Diesel | Gasoline | Diesel | Gasoline | Diesel | Gasoline | Total |
| Corn | 56, 234, 800 | 33, 740, 880 | 22, 493, 920 | 1. 38 | 1. 91 | 46, 562. 4 | 42, 963. 4 | 89, 525. 8 |
| Sorghum | 16, 695, 300 | 10, 017, 180 | 6, 678, 120 | 1. 38 | 1. 91 | 13, 823. 7 | 12, 755. 2 | 26, 578. 9 |
| Oats | 8, 581, 700 | 5, 149, 020 | 3, 432, 680 | 1. 04 | 1. 42 | 5, 355. 0 | 4, 874. 0 | 10, 299. 0 |
| Barley | 16, 475, 000 | 9, 885, 000 | 6, 590, 000 | 1. 04 | 1. 42 | 10, 280. 4 | 9, 358. 0 | 19, 638. 4 |
| Wheat [2] | 47, 273, 700 | 28, 364, 220 | 18, 909, 480 | 1. 13 | 1. 55 | 32, 051. 6 | 29, 215. 2 | 61, 266. 8 |
| Winter | 35, 455, 275 | 21, 273, 165 | 14, 182, 110 | 1. 04 | 1. 42 | 22, 124. 1 | 20, 138. 6 | 42, 262. 7 |
| Spring [3] | 11, 818, 425 | 7, 091, 055 | 4, 727, 370 | 1. 40 | 1. 92 | 9, 927. 5 | 9, 076. 6 | 19, 004. 1 |
| Rice | 2, 099, 000 | 1, 994, 050 | 104, 950 | 3. 84 | 5. 26 | 7, 657. 2 | 552. 0 | 8, 209. 2 |
| Flax | 2, 180, 500 | 545, 125 | 1, 635, 375 | 1. 40 | 1. 92 | 763. 2 | 3, 139. 9 | 3, 903. 1 |
| Soybeans | 57, 815, 900 | 34, 689, 540 | 23, 126, 360 | 1. 38 | 1. 91 | 47, 871. 6 | 44, 171. 3 | 92, 042. 9 |
| Rye | 1, 200, 000 | 720, 000 | 480, 000 | 1. 04 | 1. 42 | 748. 8 | 681. 6 | 1, 430. 4 |
| Dry edible beans | 1, 400, 000 | 840, 000 | 560, 000 | 1. 38 | 1. 91 | 1, 159. 2 | 1, 069. 6 | 2, 228. 8 |
| Dry edible peas | 135, 000 | 81, 000 | 54, 000 | 1. 38 | 1. 91 | 111. 8 | 103. 1 | 214. 9 |
| Total | 210, 090, 900 | 126, 026, 015 | 84, 064, 885 | | | 166, 384. 9 | 148, 883. 5 | 315, 268. 4 |

[1] EPAS production projections and ERS crop yield projections gave estimated acreages for corn, sorghum, oats, barley, wheat, rice, flax, and soybeans. Acreage of rye, dry edible beans and dry edible peas estimated using past trends.

[2] Assume a 75–25 percent composition of winter and spring wheat.

[3] Fuel coefficients for spring wheat include 0.35 gal./acre (gasoline) for swathing prior to combining.

Source: ERS acreage estimates, state and regional fuel coefficients.

In estimating 1980 fuel requirements for moving the combines of custom operators, it was assumed that 50 percent of the wheat, 40 percent of the barley, oats, and rye, 25 percent of the sorghum, and 15 percent of the soybean acreages in 1980 would be custom harvested. This would mean an estimated 47 million acres of these 11 crops would be custom combined in 1980. This would require 23,494 machines custom combining 2,000 acres each.

It was next necessary to predict the home States of these machines and the points to which they would travel. Such information from the 1971 ERS survey was employed in the 1980 calculations. The assumed residency composition of custom machines is as follows:

| State of residence | Combines | |
|---|---|---|
| | Number | Percent of total |
| North Dakota | 1, 739 | 7. 3 |
| South Dakota | 1, 214 | 5. 2 |
| Nebraska | 1, 567 | 6. 7 |
| Kansas | 7, 252 | 30. 9 |
| Oklahoma | 7, 181 | 30. 6 |
| Texas | 2, 670 | 11. 4 |
| Montana | 376 | 1. 6 |
| Wyoming | 94 | . 4 |
| Colorado | 1, 378 | 5. 8 |
| New Mexico | 23 | . 1 |
| Total | 23, 494 | 100. 0 |

Based on acreages harvested in various States, all crews would travel 30 million miles for the 1980 harvest (table 32). Fuel requirements for this travel would total 5.9 million gallons.

Direct fuel use for combining and hauling grain in 1980 totals 438 million gallons, of which 38 percent will be diesel fuel (table 33).

*Automobiles and trucks.*—The number of automobiles on farms in 1980 is projected at 2.36 million and the fuel used for all purposes at 1.5 billion gallons of gasoline (table 34). Motor trucks on farms will remain primarily gasoline powered. They will number an estimated 2.75 million trucks and burn 1.3 billion gallons of fuel.

*Major power machines.*—By 1980, fuel needs for major power machines—tractors, combines, trucks, and automobiles—will exceed 6.1 billion gallons assuming the same per unit fuel consumption as in 1970 (table 35). Tractors will continue to be the major users of motor fuel, consuming about half of the total. In 1980, 38 percent of motor fuel used on farms will be diesel.

TABLE 32.—TOTAL ESTIMATED MILEAGE TRAVELED BY CUSTOM COMBINES, 1980, FROM STATES OF RESIDENCE TO STATES OF DESTINATION

| State of residence | State of destination | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | North Dakota | South Dakota | Nebraska | Kansas | Oklahoma | Texas | Montana | Wyoming | Colorado | New Mexico | Total |
| North Dakota | 774, 900 | 176, 100 | 195, 600 | 913, 000 | 313, 000 | 50, 000 | ---- | ---- | 60, 900 | 87, 000 | 2, 570, 500 |
| South Dakota | 75, 100 | 667, 700 | 41, 000 | 341, 400 | 197, 300 | 112, 300 | 24, 300 | ---- | 27, 300 | ---- | 1, 486, 400 |
| Nebraska | 141, 000 | 105, 800 | 752, 200 | 229, 200 | 176, 300 | 109, 690 | 94, 020 | ---- | 82, 300 | 23, 500 | 1, 714, 010 |
| Kansas | 1, 015, 300 | 897, 400 | 407, 900 | 4, 169, 900 | 435, 100 | 815, 900 | 1, 015, 300 | ---- | 507, 640 | 199, 400 | 9, 463, 840 |
| Oklahoma | 969, 400 | 700, 100 | 807, 900 | 897, 600 | 1, 885, 000 | 448, 800 | 1, 077, 200 | 251, 300 | 1, 077, 200 | 359, 100 | 8, 473, 600 |
| Texas | 153, 500 | 370, 500 | 280, 400 | 390, 500 | 50, 100 | 2, 202, 800 | 250, 300 | 63, 400 | 867, 800 | 66, 800 | 4, 696, 100 |
| Montana | 18, 800 | 18, 800 | 28, 200 | 203, 000 | 65, 800 | 82, 300 | 293, 300 | ---- | 28, 200 | ---- | 783, 400 |
| Wyoming | ---- | ---- | 1, 900 | 73, 700 | 24, 600 | 6, 600 | ---- | 48, 900 | 6, 500 | ---- | 162, 200 |
| Colorado | 96, 460 | 31, 000 | 120, 600 | 289, 400 | 206, 700 | 156, 700 | 41, 300 | 18, 900 | 106, 100 | 12, 900 | 1, 080, 060 |
| New Mexico | 575 | 3, 220 | 690 | 1, 600 | 1, 200 | 6, 300 | 3, 100 | 1, 800 | 4, 500 | 10, 900 | 33, 885 |
| Total | | | | | | | | | | | 30, 463, 995 |

Sources: 1971 ERS Custom Combine Survey and ERS estimates.

TABLE 33.—TOTAL ESTIMATED 1980 FUEL USE FOR COMBINING AND HAULING GRAINS AND FOR MOVING CUSTOM COMBINES

| Activity | Gallons of fuel required | | |
|---|---|---|---|
| | Gasoline | Diesel | Total |
| Combining | 148, 833, 800 | 166, 384, 600 | 315, 218, 400 |
| Hauling grain | 116, 356, 527 | | 116, 356, 527 |
| Moving combines | 5, 926, 880 | | 5, 926, 880 |
| Total | 271, 117, 207 | 166, 384, 600 | 437, 501, 807 |

TABLE 34.—PROJECTED 1980 STOCK OF AUTOMOBILES AND TRUCKS AND FUEL USE, BY SIZE OF FARM

| Item | Size of farm (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | 1–99 | 100–179 | 180–259 | 260–499 | 500 or more | |
| Automobiles: | | | | | | |
| Number (gasoline only) | 642. 766 | 373. 619 | 323. 595 | 482. 327 | 538, 194 | 2, 360, 501 |
| Gallons per unit [1] | 567 | 558 | 573 | 638 | 781 | 630 |
| Total gallons used (1,000 gallons) | 364, 448 | 208, 479 | 185, 420 | 307, 725 | 420, 330 | 1, 486, 402 |
| Trucks: | | | | | | |
| Gasoline: | | | | | | |
| Number | 540, 526 | 342, 233 | 325, 803 | 524, 393 | 975, 416 | 2, 708, 371 |
| Gallons per unit [1] | 390 | 382 | 400 | 456 | 591 | 476 |
| Total gallons used | 210, 805, 140 | 130, 733, 006 | 130, 321, 200 | 239, 123, 208 | 576, 470, 856 | 1, 287, 453, 410 |
| Diesel: | | | | | | |
| Number | 0 | 6, 984 | 3, 291 | 10, 702 | 19, 906 | 40, 883 |
| Gallons per unit [1] | | 462 | 320 | 628 | 596 | 560 |
| Total gallons used | 0 | 3, 225, 309 | 1, 052, 229 | 6, 725, 113 | 11, 871, 883 | 22, 874, 534 |
| All | 540, 526 | 349, 217 | 329, 094 | 535, 095 | 995, 322 | 2, 749, 254 |

[1] 1970 ERS/SRS Petroleum Use in Farming Survey.

TABLE 35.—PROJECTED 1980 DIESEL FUEL AND GASOLINE CONSUMPTION BY MAJOR MACHINES ON AND DIRECTLY RELATED TO FARMS

[In millions of gallons]

| Use of fuel | Quantity of fuel used | | |
|---|---|---|---|
| | Gasoline | Diesel | Total |
| Tractors | 880 | 2, 155 | 3, 035 |
| Combines | 149 | 166 | 315 |
| Autos and trucks | 2, 774 | 23 | 2, 797 |
| Total | 3, 803 | 2, 344 | 6, 147 |

## Fuel Conservation Measures

The growing use of energy in agriculture and the present energy supply problems have prompted some scientists to question the advisability of continuing the trend toward fossil fuel-based technology in U.S. agriculture [43]. This has prompted others to investigate energy use in the U.S. food system [32]. In addition to a four-fold increase in energy use on farms between 1940 and 1970, they estimated a three-fold increase in the food processing industry and the commercial and home sectors during the same period. And the growth in energy input to the food system does not appear to be abating.

Plotting farm output against the energy input to the U.S. food system between 1920 and 1970, they found a curve that was similar

to most growth curves and concluded that further increases in food production from increasing energy inputs will be harder and harder to come by. The suggested solution was to find means to reduce the energy required for agriculture and the food system.

In that vein, others investigated changes in energy use in agriculture and outlined a few alternatives that could reduce energy inputs required for agricultural production.

The efforts of these scientists are commendable—they were among the first to relate the energy problem to our food supply. Their attempt to suggest alternative means of conserving scarce energy resources in the food system is also a necessary step in the right direction. However, their work largely ignored the economic forces that have contributed to the pattern of energy use in the food system. From their data, it can be seen that energy output is increasing more rapidly than the energy input. Between 1954 and 1959 and between 1959 and 1964 the increase in energy output was four times the increase in energy input [43]. Between 1964 and 1970, this ratio of change had declined to two (table 36). The data suggest that corn producers are getting less output per unit of energy input than in the earlier years. However, they are still obtaining two units of output for each unit of input. The value of both inputs and output increased during the 1959–73 period (table 37). However, the change in value of output was two to three times the change in the value of inputs for each of the observations.

TABLE 36.—ENERGY INPUTS AND OUTPUT (KILOCALORIES) IN CORN PRODUCTION

| Input | 1950 | 1954 | 1959 | 1964 | 1970 |
|---|---|---|---|---|---|
| Labor | 9,800 | 9,300 | 7,600 | 6,000 | 4,900 |
| Machinery | 250,000 | 300,000 | 350,000 | 420,000 | 420,000 |
| Gasoline | 615,800 | 688,300 | 724,500 | 760,700 | 797,000 |
| Nitrogen | 126,000 | 226,800 | 344,400 | 487,200 | 940,000 |
| Phosphorus | 15,200 | 18,200 | 24,300 | 27,400 | 47,100 |
| Potassium | 10,500 | 50,400 | 60,400 | 68,000 | 68,000 |
| Seeds for planting | 40,400 | 18,900 | 36,500 | 30,400 | 63,000 |
| Irrigation | 23,000 | 27,000 | 31,000 | 34,000 | 34,000 |
| Insecticides | 1,100 | 3,300 | 7,700 | 11,000 | 11,000 |
| Herbicides | 600 | 1,100 | 2,800 | 4,200 | 11,000 |
| Drying | 30,000 | 60,000 | 100,000 | 120,000 | 120,000 |
| Electricity | 54,000 | 100,000 | 140,000 | 203,000 | 310,000 |
| Transportation | 30,000 | 45,000 | 60,000 | 70,000 | 70,000 |
| Total inputs | 1,206,400 | 1,548,300 | 1,889,200 | 2,241,900 | 2,896,800 |
| Corn yield (output) | 3,830,400 | 4,132,800 | 5,443,200 | 6,854,400 | 8,164,800 |

Source: (4).

TABLE 37.—COST OF ENERGY INPUTS PER ACRE OF CORN PRODUCTION, SELECTED YEARS

| Inputs | 1959 | 1964 | 1970 | 1973 |
|---|---|---|---|---|
| Labor | $13.30 | $11.88 | $14.76 | $19.80 |
| Machinery | 8.97 | 9.96 | 12.84 | 14.77 |
| Gasoline | 5.32 | 5.69 | 6.78 | 10.16 |
| Nitrogen | 3.67 | 4.47 | 5.10 | 12.54 |
| Phosphorus | 3.22 | 3.59 | 5.80 | 8.68 |
| Potassium | 1.71 | 1.71 | 3.06 | 4.86 |
| Seed | 3.36 | 3.96 | 5.18 | 7.77 |
| Irrigation | .26 | .31 | .34 | .70 |
| Insecticides | .53 | 1.43 | 3.47 | 6.94 |
| Herbicides | .01 | .60 | .84 | 1.68 |
| Drying | .49 | .62 | .71 | 1.07 |
| Electricity | 1.30 | 1.93 | 2.71 | 2.98 |
| Transportation | .42 | .49 | .56 | .84 |
| Total value of inputs | 42.56 | 46.64 | 62.15 | 92.79 |
| Value of corn output | 60.48 | 74.12 | 103.68 | 205.74 |

Although it is not possible to use these data in prescriptive analysis, they do suggest that there was little economic incentive to reduce the use of energy in U.S. farm production. Quite the contrary, the incentive was to do exactly as producers were doing—increase the use of energy.

In considering the conservation of energy, it is useful to partition the energy inputs into two components—those that expand the area cultivated per worker or material handled per worker and those used chiefly to increase output per unit of area, or to prevent loss of production or product.

With this stratification of the energy input in corn production, data for 1970 suggest there was little incentive to substitute labor for much other technology used in agriculture. At 1970 prices, 1,000 kilocalories of inputs which expand the area cultivated or material handled per worker cost about 1.5 cents, compared with 1,000 kilocalories of labor costing $3. Thus, the frequent suggestion by those looking only at physical data that farmers should adopt less energy intensive technologies including the substitution of labor for other inputs is not supported on economic grounds.

As for the yield-increasing energy inputs, the data show an increase of 2.6 kilocalories of corn production associated with an increase of each kilocalorie of input between 1964 and 1970. It is little wonder that we have observed the growth in the use of such inputs as fertilizer and pesticides in corn production during this period.

Under the Mandatory Petroleum Allocation Program, farmers are to receive 100 percent of their fuel needs. However, they are to institute conservation measures to save fuel. The Extension Service has published a number of practices that farmers can follow to comply with this requirement and to lower fuel costs. Reduced tillage practices is a major means of achieving these goals.

Currently, about 18 percent of tilled cropland is farmed with reduced- or no-till operations. However, there is a potential economic force that causes this practice to be attractive. While the reduced tillage practice saves fuel, it also saves labor. In April 1974, with fuel prices 50 percent higher than in 1973 and wages 10 percent higher, these inputs for conventional tillage practices cost $1 more per acre in April 1974 than in 1973 (table 38). Farmers can significantly reduce the cost of these inputs by shifting from conventional to reduced-tillage practices. However, the greater economic saving is from reduced labor cost. From a fossil fuel standpoint, although the direct use of energy is reduced, increased use of pesticides and the energy required to produce reduced-tillage equipment are partly offsetting.

TABLE 38.—COST OF FUEL AND LABOR PER ACRE OF ROW CROPS BY DIFFERENT METHODS OF TILLAGE[1]

[Dollars per acre]

| Item | Methods of tillage: Conventional | Reduced | Minimum | No-till |
|---|---|---|---|---|
| 1973:[2] | | | | |
| Diesel fuel | 1.15 | 0.65 | 0.53 | 0.19 |
| Labor | 3.96 | 2.42 | 2.38 | 1.56 |
| Total | 5.11 | 3.07 | 2.91 | 1.75 |
| 1974:[3] | | | | |
| Diesel fuel | 1.73 | .98 | .80 | .29 |
| Labor | 4.38 | 2.67 | 2.63 | 1.72 |
| Total | 6.11 | 3.65 | 3.43 | 2.01 |

[1] From USDA, ES, Fact Sheet No 4, June 26, 1973.
[2] Diesel fuel priced at 21.6¢ per gallon and labor at $2 per hour without board or room (1973 U.S. averages).
[3] Diesel fuel priced at 150 percent of 1973 average or 32.4¢ per gallon; labor priced at $2.21, the Apr. 1, 1974, U.S. average rate without room or board.

TABLE 39.—POTENTIAL REDUCTIONS IN 1980 AGRICULTURAL FUEL USE WITH REDUCED- OR NO-TILLAGE ACTIVITIES

[Million gallons]

| If tillage activities were reduced by: | Estimated fuel use for 1980 tillage would be: Diesel | Gasoline | Total estimated tractor fuel use would be: Diesel | Gasoline | Fuel savings over conventional tillage would be: Diesel | Gasoline |
|---|---|---|---|---|---|---|
| 0 | 1,508 | 616 | 2,155 | 880 | 0 | 0 |
| 10 | 1,358 | 554 | 2,005 | 818 | 150 | 62 |
| 20 | 1,207 | 493 | 1,854 | 757 | 301 | 123 |
| 30 | 1,056 | 431 | 1,703 | 695 | 452 | 185 |
| 40 | 905 | 370 | 1,552 | 634 | 603 | 246 |
| 50 | 754 | 308 | 1,401 | 572 | 754 | 308 |
| 60 | 603 | 246 | 1,250 | 510 | 905 | 370 |
| 70 | 453 | 185 | 1,100 | 449 | 1,055 | 431 |
| 80 | 302 | 123 | 949 | 387 | 1,206 | 493 |
| 90 | 151 | 62 | 798 | 326 | 1,357 | 554 |
| 100 | 0 | 0 | 647 | 264 | 1,508 | 616 |

*Possible fuel impacts of reduced tillage practices*

Reduced—or no-tillage practices are becoming more common throughout the country, as farmers have discovered several important advantages in reduced tillage operations, and the significance of such practices will likely increase in the future. In some cases, "no-tillage" is practiced, which consists of planting the selected crop directly through the stubble or sod from a previous crop with no ensuing tillage. In other cases, the practice of reduced or minimum tillage may include some or most conventional tillage operations up to planting time and little or no tillage thereafter. In any case, advantages include reduced soil compaction and erosion, greater water conservation, and lower expenditures for labor, fuel, lubrication, and equipment repair. On the average, 70 percent of tractor horsepower-hours are used in plowing and other tillage operations, while harvesting and hauling and other operations comprise the remainder.

Significant reductions in fuel usage by tractors may be realized by further adoption of reduced tillage operations. Considering total projected 1980 tractor fuel usage, the estimated 70 percent of tractor hours used for plowing and other tillage activities would require 616 million gallons of gasoline and 1.5 billion gallons of diesel. A 20 percent reduction in tillage activities could reduce fuel requirements for

tractors by about 425 million gallons. Table 39 illustrates predicted fuel savings from various reductions in the intensity of tillage operations. Should reduced- or no-tillage cultivating become more widespread by 1980, the effects on economy in fuel use may be quite profound.

With 6.8 billion gallons of petroleum fuel used in power machines, proper maintenance is essential for optimum fuel consumption. Improperly maintained equipment will consume 10–15 percent more fuel than that which is tuned.

There are other conservation measures of importance to farmers. Instead of irrigating on a time sequence, growers could use moisture sensing blocks to determine when the crops actually need water and then apply only the amount needed.

Farmers should have soil tested annually and apply only the amount and type of fertilizer recommended for the crop to be planted. To the extent possible, they should use high analyses fertilizers to avoid unnecessary processing and transporting of inert materials.

TABLE 40.—FUEL CONSUMPTION PER ACRE, GALLONS OF FUEL USED BY TYPE OF FUEL, KIND OF MACHINE, AND SIZE OF FARM, UNITED STATES, 1970 [1]

[Gallons per acre]

| Farm size and fuel type | Power units | | | | |
|---|---|---|---|---|---|
| | Tractor | Combines and other pickers [2] | Trucks and automobiles | Other | Total |
| All farms: | | | | | |
| Gasoline | 6.2 | 1.0 | 11.1 | 0.3 | 18.6 |
| Diesel | 5.7 | .2 | .1 | | 6.0 |
| LP gas | 1.1 | .6 | .1 | | 1.8 |
| Total | 13.0 | 1.8 | 11.3 | .3 | 26.4 |
| 1 to 99 acres: | | | | | |
| Gasoline | 19.5 | 1.0 | 54.0 | .5 | 75.0 |
| Diesel | 3.4 | .1 | .1 | | 3.6 |
| LP gas | .8 | .3 | | | 1.1 |
| Total | 23.7 | 1.4 | 54.1 | .5 | 79.7 |
| 100 to 179 acres: | | | | | |
| Gasoline | 11.5 | .7 | 17.5 | .1 | 29.8 |
| Diesel | 2.6 | .1 | .1 | | 2.8 |
| LP gas | .6 | .1 | | | .7 |
| Total | 14.7 | .9 | 17.6 | .1 | 33.3 |
| 180 to 259 acres: | | | | | |
| Gasoline | 9.5 | .8 | 11.9 | .2 | 22.4 |
| Diesel | 3.6 | .1 | | | 3.7 |
| LP gas | .6 | .2 | | | .8 |
| Total | 13.7 | 1.1 | 11.9 | .2 | 26.9 |
| 260 to 499 acres: | | | | | |
| Gasoline | 6.7 | 1.0 | 8.4 | .2 | 16.3 |
| Diesel | 4.6 | .1 | .1 | | 4.8 |
| LP gas | 1.0 | .7 | .1 | | 1.8 |
| Total | 12.3 | 1.8 | 8.6 | .2 | 22.9 |
| Over 500 acres: | | | | | |
| Gasoline | 2.9 | 1.1 | 6.5 | .4 | 10.9 |
| Diesel | 7.5 | .3 | .1 | | 7.9 |
| LP gas | 1.3 | .8 | .2 | | 2.3 |
| Total | 11.7 | 2.2 | 6.8 | .4 | 21.1 |

[1] Total acres of land in farm.
[2] Includes cotton pickers.

Source: USDA 1970 fuel use survey.

They could use high yielding hybrid seed varieties, and for corn to be fed to hogs adopt high-lysine varieties to reduce the amount of feed supplements needed.

With higher yields and nominal exports, less land will be needed for crop production in years ahead. As land becomes available, farmers could engage in crop rotation with spatial separation to help control insects and diseases. This will permit conservation of use of chemical pesticides.

Livestock producers could insulate their animal maternity pens and broiler houses to reduce the amount of artificial heat required. They should also consider using windmills for power to fill stock tanks.

Farmers could eliminate unnecessary hedgerows, and fences that cut up their farms into small fields. An example of the effect that farm size has on fuel use per acre is shown in table 40 where farms of less than 100 acres use 3–4 times as much fuel per acre as those over 180 acres.

## Fuel Used for Family Living

In 1970 farm families used for family living purposes an estimated 36 billion cubic feet of natural gas from public utilities, 850 million gallons of fuel oil, 1 million tons of coal, 26 million barrels of LP gas (primarily propane and butane), and 23 billion kilowatt hours of electricity. This totaled nearly 368 trillion Btu (table 41).

For other than electricity, space heating consumed most of the fuels used for family living. In 1970, only 11 percent of farm household electricity was used in space heating. LP gas and natural gas are used for both space heating and cooking, but space heating consumed about three-fourths of these fuels. In total, space heating consumed 70 percent of all household Btu (table 42).

Fuel oil, including kerosene, was the most widely used fuel to heat farm homes in 1970 with 36 percent of all farm homes so heated [7]. Over 31 percent of the homes were heated by LP gas; 10 percent by utility (natural) gas; 8 percent by electricity; 8 percent by coal or coke; and 7 percent by wood and other sources. Fuel for heating by wood and other sources are excluded from these estimates.

Farm families in Federal Region V consumed more natural gas, fuel oil, coal and electricity than did farmers in any other region. There are more farm homes there than any other region except Region IV and the climate is cold. For States and number of farms in each region, see figure 4. Farmers in Region VII were the next largest consumers of natural gas.

The consumption of fuel in farm households is highly seasonal, largely the result of varying space heating requirements throughout the year. Space heating needs vary from region to region, but in general about 85 percent of the heating fuel is consumed during November–March (table 43). With only a short winter season, Region VI consumes 92 percent of its space heating fuel during the 5-month period while Regions I, VIII, IX, and X use less than 80 percent during this time; as space heating continues throughout much of the year.

Between 1960 and 1970 the type of fuel used in heating of farm homes shifted markedly. The proportion of farm homes using wood declined 78 percent and those using coal declined 66 percent. Electric

heating increased most rapidly to 267 percent of its 1960 level. Utility gas showed a 128 percent increase while homes heated with LP gas increased 24 percent.

*Family transportation*

The amount of fuel used in the farm automobiles for family living is difficult to determine. In a 1970 ERS/SRS survey of petroleum fuel needs in farming, nearly 20,000 respondents reported using an average of 610 gallons per auto. In previous surveys, farmers had reported that 25 percent of the automobile use was for business purposes. Thus, an estimated 458 gallons of fuel per automobile or 1.2 billion gallons was determined to be for family living purposes.

TABLE 41.—ESTIMATED FUEL USED IN FARM HOMES FOR FAMILY LIVING, BY TYPE OF FUEL AND REGION, 197 AND 1980

| Standard Federal Regions | Utility gas [1] (million cubic feet) | Fuel oil (million gallons) | Coal (1,000 tons) | Electricity (million kilowatt hours) | LP gas [2] (1,000 barrels) | All fuels (billion Btu) |
|---|---|---|---|---|---|---|
| 1970 | | | | | | |
| I | 100 | 28 | 5,253 | 300 | 49 | 5,383 |
| II | 853 | 37 | 25,696 | 595 | 55 | 8,956 |
| III | 2,326 | 78 | 186,199 | 1,910 | 166 | 25,178 |
| IV | 4,737 | 87 | 217,042 | 5,641 | 1,645 | 48,393 |
| V | 9,826 | 381 | 394,538 | 5,861 | 5,883 | 116,983 |
| VI | 7,224 | 1 | 2,614 | 2,492 | 6,020 | 40,695 |
| VII | 6,200 | 111 | 61,223 | 3,112 | 8,846 | 69,892 |
| VIII | 3,159 | 85 | 112,371 | 1,502 | 2,596 | 33,521 |
| IX | 1,274 | 2 | 166 | 695 | 530 | 6,057 |
| X | 573 | 44 | 30,524 | 1,310 | 231 | 12,810 |
| United States | 36,272 | 854 | 1,035,626 | 23,418 | 26,021 | 367,868 |
| 1980 | | | | | | |
| I | 118 | 16 | 1,917 | 272 | 34 | 3,498 |
| II | 1,002 | 21 | 9,379 | 539 | 54 | 6,313 |
| III | 2,733 | 45 | 67,963 | 1,773 | 161 | 17,519 |
| IV | 5,566 | 50 | 79,220 | 5,376 | 4,882 | 52,922 |
| V | 11,545 | 220 | 144,006 | 5,759 | 5,713 | 88,986 |
| VI | 8,488 | 1 | 954 | 3,045 | 5,846 | 43,062 |
| VII | 7,286 | 64 | 22,346 | 3,404 | 8,590 | 63,489 |
| VIII | 3,712 | 49 | 41,015 | 1,581 | 2,521 | 27,284 |
| IX | 1,497 | 1 | 61 | 768 | 514 | 6,384 |
| X | 673 | 25 | 11,141 | 1,352 | 224 | 9,986 |
| United States | 42,620 | 492 | 378,002 | 23,869 | 28,539 | 319,443 |

[1] Natural gas furnished by public utilities.
[2] Primarily propane and butane in bottles or tanks.

TABLE 42.—ESTIMATED FUEL USED FOR SPACE HEATING IN FARM HOMES, BY TYPE OF FUEL AND REGION, 1970 AND 1980

| Standard Federal Regions | Utility gas [1] (million cubic feet) | Fuel oil (million gallons) | Coal (1,000 tons) | Electricity (million kilowatt hours) | LP gas [2] (1,000 barrels) | All fuels (billion Btu) |
|---|---|---|---|---|---|---|
| 1970 | | | | | | |
| I | 84 | 28 | 5, 253 | 28 | 41 | 4, 403 |
| II | 665 | 37 | 25, 696 | 27 | 43 | 6, 773 |
| III | 1, 805 | 78 | 186, 199 | 181 | 129 | 18, 584 |
| IV | 3, 272 | 87 | 217, 042 | 117 | 83 | 21, 707 |
| V | 8, 148 | 381 | 394, 538 | 694 | 4, 873 | 93, 511 |
| VI | 4, 748 | 1 | 2, 614 | 248 | 3, 948 | 22, 057 |
| VII | 4, 996 | 111 | 61, 223 | 372 | 7, 119 | 52, 279 |
| VIII | 2, 679 | 85 | 112, 371 | 293 | 2, 199 | 27, 288 |
| IX | 775 | 2 | 166 | 136 | 321 | 2, 784 |
| X | 453 | 44 | 30, 524 | 408 | 183 | 9, 412 |
| United States | 27, 625 | 854 | 1, 035, 626 | 2, 504 | 18, 939 | 258, 798 |
| 1980 | | | | | | |
| I | 99 | 16 | 1, 917 | 39 | 40 | 2, 708 |
| II | 782 | 21 | 9, 379 | 38 | 42 | 4, 325 |
| III | 2, 120 | 45 | 67, 963 | 252 | 125 | 11, 546 |
| IV | 3, 845 | 50 | 79, 220 | 162 | 3, 366 | 27, 190 |
| V | 9, 574 | 220 | 144, 006 | 967 | 4, 732 | 66, 609 |
| VI | 5, 579 | 1 | 954 | 346 | 3, 834 | 22, 664 |
| VII | 5, 870 | 64 | 22, 346 | 518 | 6, 913 | 45, 362 |
| VIII | 3, 148 | 49 | 41, 015 | 408 | 2, 136 | 21, 135 |
| IX | 910 | 1 | 61 | 189 | 312 | 2, 976 |
| X | 532 | 25 | 11, 141 | 568 | 177 | 6, 973 |
| United States | 32, 459 | 492 | 378, 002 | 3, 487 | 21, 677 | 211, 488 |

[1] Natural gas furnished by public utilities.
[2] Primarily propane and butane in bottles and tanks.

TABLE 43.—PERCENTAGE DISTRIBUTION OF ENERGY REQUIREMENTS NEEDED TO HEAT FARM HOUSING UNITS BY MONTH, BY REGION, 1970

[In percent]

| Standard Federal region | Month | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | January | February | March | April | May | June | July | August | September | October | November | December | |
| I | 19.1 | 16.9 | 14.6 | 8.7 | 3.7 | 0.7 | | 0.3 | 1.6 | 6.0 | 11.0 | 17.4 | 100.0 |
| II | 20.0 | 18.0 | 15.6 | 8.5 | 2.5 | .2 | | | .7 | 4.9 | 11.2 | 18.5 | 100.0 |
| III | 19.4 | 17.2 | 14.6 | 7.5 | 2.6 | .4 | | .1 | 1.4 | 5.9 | 12.3 | 18.5 | 100.0 |
| IV | 22.3 | 18.3 | 14.3 | 4.9 | 1.0 | | | | .6 | 4.0 | 13.3 | 21.3 | 100.0 |
| V | 19.2 | 16.7 | 14.4 | 7.9 | 3.5 | .8 | 0.1 | .1 | 1.6 | 5.8 | 12.2 | 17.8 | 100.0 |
| VI | 24.7 | 17.9 | 13.4 | 4.1 | .4 | | | | .1 | 3.1 | 14.1 | 22.1 | 100.0 |
| VII | 21.1 | 17.3 | 14.2 | 6.6 | 2.6 | .4 | | .1 | 1.2 | 5.2 | 12.7 | 18.8 | 100.0 |
| VIII | 18.5 | 15.3 | 13.7 | 8.2 | 4.3 | 1.4 | .2 | .3 | 2.2 | 6.7 | 12.8 | 16.5 | 100.0 |
| IX | 19.6 | 15.0 | 13.4 | 8.9 | 5.0 | 2.5 | 2.0 | 1.1 | 1.7 | 3.8 | 10.4 | 16.6 | 100.0 |
| X | 16.8 | 13.5 | 12.6 | 8.8 | 5.5 | 2.7 | 1.0 | 1.1 | 3.0 | 7.5 | 12.5 | 15.2 | 100.0 |
| United States | 21.1 | 17.2 | 14.1 | 6.4 | 2.4 | .5 | .1 | .1 | 1.1 | 4.9 | 12.8 | 19.3 | 100.0 |

Source: Statistical Abstract of United States, 1970. Number of farm households multiplied by annual degree days (65 degree base—for selected cities for 1930–1960). Farm households from Statistical Bulletin No. 507, Statistical Reporting Service, U.S. Dept. Agr.

Farm family members also use trucks—particularly pick-ups—for family living purposes. In previous fuel surveys, farmers estimated as much as 25 percent of truck fuel was for family use [52]. Applying the same percentage to 1970 truck fuel use indicates that farm family members used 355 million gallons in trucks for family living purposes.

In 1972, a major ERS survey of farm production expenditures for 1971 was conducted. Fuel use in automobiles was reported sharply higher—2.6 billion gallons for 2.6 million automobiles or 1,000 gallons per auto. Again, farmers reported automobile for business use at about 25 percent. This leaves 750 gallons per auto for family living.

The higher estimates may be rationalized by the fact that many farm families have members having non-farm occupations that require commuting long distances daily. Even though some of these people may not have worked on farms their vehicles and fuel consumption were enumerated if they resided on farms. The 1970 survey was oriented more to farm production use.

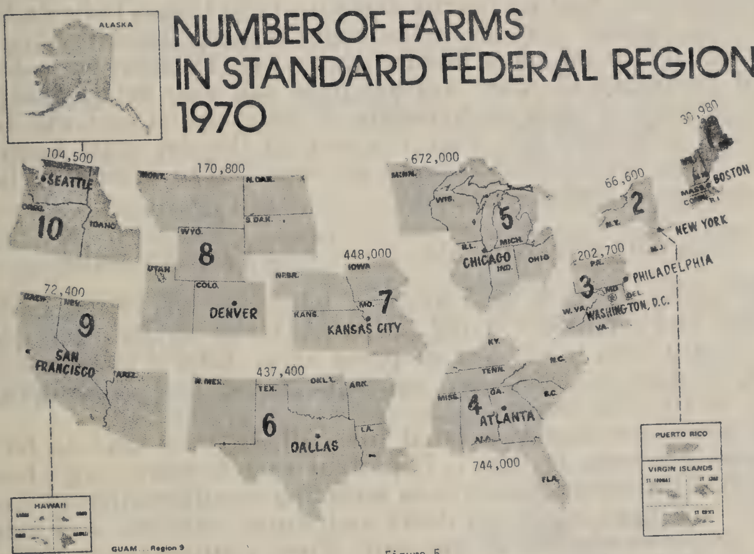


Figure 5

FIGURE 5

*Projections for 1980*

By 1980 the number of farm homes is expected to decrease about 21 percent to 2.33 million. But, because of shifts in fuel usage, this smaller number of farm families is expected to use greater quantities of certain types of fuel for family living purposes than did the larger number in 1970. Natural gas, LP gas, and electricity are expected to increase in use by 18, 10, and 2 percent, respectively. In total the 1980 farm household fuel use is expected to reach 320 trillion Btu, 87 percent of the amount used in 1970 (table 41). Space heating needs by 1980 are expected to decline more than total household energy needs and are projected to be only 82 percent of the 1970 level (table 42).

Increased household energy use is indicated in Regions IV, VI, and IX. This results primarily from a projected shift in space heating fuels to natural gas and electricity.

TABLE 44.—IMPORTANCE OF FUEL TYPES FOR SPACE HEATING FARM HOMES, 1970 AND 1980

| Type of fuel | 1970 | 1980 |
|---|---|---|
| | Billion Btu's | |
| Natural gas | 28,592 | 33,595 |
| Fuel oil | 118,385 | 68,308 |
| Coal | 26,305 | 9,601 |
| Electricity | 8,542 | 11,891 |
| LP gas | 76,974 | 88,093 |
| All fuels | 258,798 | 211,488 |
| | Percent of all fuels | |
| Natural gas | 11.0 | 15.9 |
| Fuel oil | 45.8 | 32.3 |
| Coal | 10.2 | 4.5 |
| Electricity | 3.3 | 5.6 |
| LP gas | 29.7 | 41.7 |
| All fuels | 100.0 | 100.0 |

Projected space heating requirements for farm homes indicate that LP gas will supplant fuel oil as the major heating fuel providing 42 percent of all Btu for space heating (table 44). Demand for natural gas and electricity as space heating fuels will also be up sharply. Fuel oil demand is expected to decline 42 percent and coal will drop 64 percent, to provide less than 5 percent of Btu for space heating.

Farm family transportation needs are expected to decline by 1980 as the number of farms decrease.

## Fuel Conservation Measures for Family Living

Farm families in 1970 used nearly 2 billion gallons of automobile and truck fuel for family living purposes. Many families live quite some distance from towns and shopping areas. Efforts to reduce the number of trips to town can significantly cut fuel consumption; perhaps by 10 to 15 percent.

With most farm homes isolated from others, they tend to be in windswept locations. It thus is important that farmers adopt home heating fuel conservation measures including weatherstripping doors and windows, applying storm doors and storm windows, and maintaining proper insulations in the attic. Trees planted as windbreaks should also be helpful.

Within the home farmers should consider replacing frost-free refrigerators and freezers with the less energy consuming standard models as their current appliances wear out.

Farmers, like all other householders, should maintain a winter temperature of 68 F. A day-night timed thermostat should be considered.

# FOOD PROCESSING

Many farm products are not in a form desirable for human consumption and must be processed to be edible. Other products are highly perishable in the raw state and must be canned or frozen to make them storable. Processing of agricultural products for human consumption requires a considerable amount of heat and power.

In 1971, energy used for heat and power in the food and kindred products industry group totaled 302 billion kilowatt-hours equivalent, or 7.8 percent of the heat and power energy used in all manufacturing industries (table 45).[2] Of the 20 major group manufacturing industries (2 digit SIC code),[3] the food and kindred products industry (SIC 20) which includes establishments manufacturing or processing foods and beverages for human consumption ranked sixth in the amount of energy used for heat and power in 1971. However, fuel used by the food group failed to keep pace with that used in all manufacturing, declining from 11 percent of total fuel use in 1954 to 8 percent in 1971.

The manufacturing industries include establishments engaged in the mechanical or chemical transformation of materials or substances into new products. These industries used 3,850 billion kilowatt-hours equivalent of purchased fuels and electric energy for heat and power in 1971, up 73 percent from 1954 when the figure was 2,220 billion kilowatt-hours equivalent.

TABLE 45.—ENERGY USED FOR HEAT AND POWER FOR ALL MANUFACTURING AND THE FOOD AND KINDRED PRODUCTS INDUSTRY GROUP: SELECTED YEARS, 1954–71

| Year | All manufacturing, billion kilowatt-hour equivalent [1] | Food and kindred products industry group | |
|---|---|---|---|
| | | Billion kilowatt-hour equivalent [1] | Percentage of total |
| 1954 | 2,220 | 236 | 10.6 |
| 1958 | 2,417 | 225 | 9.3 |
| 1962 | 2,875 | 235 | 8.1 |
| 1967 | 3,461 | 264 | 7.6 |
| 1971 | 3,850 | 302 | 7.8 |

[1] Represents the kilowatt-hour equivalents of all fuels (fuel oil, coal, and natural gas) plus electricity used for heat and power.

[2] These data are from the U.S. Department of Commerce, Census of Manufacturing, which publishes data on fuels and electric energy used for heat and power in manufacturing. Throughout this section the terms "purchased fuels" and "electric energy" will be used in discussing the data. Purchased fuels refers to the fuel oil, coal, coke, natural gas, and other fuels not specified by kind used by an establishment for heat and power. Electric energy represents the amount actually purchased from other establishments and does not include the electricity generated and used within the establishment.

[3] The Standard Industrial Classification (SIC) system is used to identify industries. The SIC code classifies establishments by type of manufacturing or processing activity in which they are engaged. The SIC provides for: major group level, 2-digit code; industry group, 3-digit code; and industry, 4-digit code.



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TABLE 46.—PURCHASED FUELS AND ELECTRIC ENERGY USED IN THE FOOD AND KINDRED PRODUCTS GROUP, BY INDUSTRY GROUP, 1971

| Industry group | SIC code | Purchased fuels and electric energy | | | |
|---|---|---|---|---|---|
| | | Value (millions) | Industry rank[1] | As a percentage of— Value of shipments | Cost of all materials |
| Meat products | 201 | $130.8 | 16 | 0.5 | 0.6 |
| Dairy products | 202 | 123.2 | 20 | .8 | 1.1 |
| Canned and preserved fruits and vegetables | 203 | 124.4 | 18 | 1.0 | 1.7 |
| Grain mill products | 204 | 118.1 | 21 | 1.1 | 1.5 |
| Bakery products | 205 | 66.5 | 39 | .9 | 2.1 |
| Sugar | 206 | 61.1 | 45 | 2.3 | 3.0 |
| Confectionary products | 207 | 27.3 | 82 | .8 | 1.5 |
| Beverages | 208 | 109.2 | 22 | .8 | 1.6 |
| Miscellaneous food preparations and kindred products | 209 | 136.0 | 14 | 1.1 | 1.1 |
| Total | | 896.6 | | .9 | 1.3 |

[1] This industry rank relates to all 3-digit industry groups in manufacturing.

The 146 industry groups (3 digit SIC code) in manufacturing spent $10 billion for heat and power in 1971. The 9 industry groups in food and kindred products processing spent $896.6 million—8.6 percent of the total (table 46). Thus, fuel costs to the food group were higher than average as they spent 8.6 percent of the total dollar outlay for 7.8 percent of the fuel. The miscellaneous food and kindred products industry group (SIC 209) spent the most for heat and power—$136 million; the confectionary products industry group (SIC 207) spent the least—$27.3 million. These amounts are quite small compared with the $1,250.5 million spent for heat and power in the blast furnace and basic steel products industry group (SIC 331) and the $1,119.4 million in the industrial chemicals industry group (SIC 281). But the industry groups engaged in the processing of agriculture products rank relatively high in the amount spent for heat and power. In 1971, 6 of these industry groups ranked in the top 22 industry groups in the amount spent for heat and power.

Total value of shipments from all manufacturing industries was $671 billion in 1971. The food and kindred products group (SIC 20) had shipments valued at $104 billion—15.5 percent of the total. The ratio of dollars spent for heat and power to value of shipments varied from 15.6 percent for the hydraulic cement industry group (SIC 324) to 0.2 percent for periodicals (SIC 272). Food and kindred products share ranged from 2.3 percent for sugar to 0.5 percent for meat products.

Total cost of materials used by manufacturing was $356 billion in 1971. The food and kindred products industry group accounted for

19.7 percent. Of the $70 billion spent for materials in this group, $897 million, or 1.3 percent, went for purchased fuels and electric energy used for heat and power. The amount spent on fuels and electric energy in relation to the cost of all materials ranged from 3 percent in the sugar products industry group to 0.6 percent in the meat products industry group.

Over time, not only has the quantity of energy used for heat and power increased in the food and kindred products industry group but also a shift has occurred in the relative importance of various fuels. The use of electricity has risen steadily from 14 billion kilowatt-hours in 1954 to 38.1 billion kilowatt-hours in 1971 (table 47). Natural gas use has also gone up dramatically, from 262.9 billion cubic feet in 1954 to 478.5 billion cubic feet in 1971. In 1971, natural gas accounted for 53 percent and electricity for 14 percent of the energy used for heat and power, up from 43 percent and 9 percent, respectively, in 1962. The total amount of fuel oil used has ranged between 17.5 million and 21 million barrels. However, the distribution between distillate and residual oil has changed over time. Residual oil accounted for 12 percent and distillate oil 4 percent of the energy used for heat and power in the food and kindred products group in 1962. By 1971, residual and distillate oil each accounted for 7 percent of the energy requirements. Coal use has declined steadily, tonnage decreasing 60 percent from 1954 to 1971. Importance of coal use has also fallen—29 percent of the energy needed for heat and power in 1962 to 13 percent in 1971. A small amount of coke was used, primarily in the beet sugar refining industry.

In total, the food group increased consumption of fuel use 49 percent from 1954 to 1972 (table 48). At the same time, value added by manufacture decreased 1 percent.

TABLE 47.—PURCHASED FUELS USED FOR HEAT AND POWER IN THE FOOD AND KINDRED PRODUCTS INDUSTRY GROUP, SELECTED YEARS, 1954–71

| Year | Electric energy [1] (million kilowatt-hours) | Fuel oil (thousand barrels) | | Coal [3] (thousand short-tons) | Coke (thousand short-tons) | Natural gas (billion cubic feet) |
|---|---|---|---|---|---|---|
| | | Distillate [2] | Residual [2] | | | |
| 1954 | 13,972 | (4) | (4) | 11,179 | 99 | 262.9 |
| 1958 | 18,044 | (4) | (4) | 8,663 | 65 | 243.9 |
| 1962 | 21,498 | 5,445 | 15,600 | 8.752 | 70 | 330.3 |
| 1967 | 26,788 | 8,095 | 9,439 | 6,600 | 56 | 346.3 |
| 1971 | 38,086 | 10,891 | 9,872 | 4,456 | 154 | 478.5 |

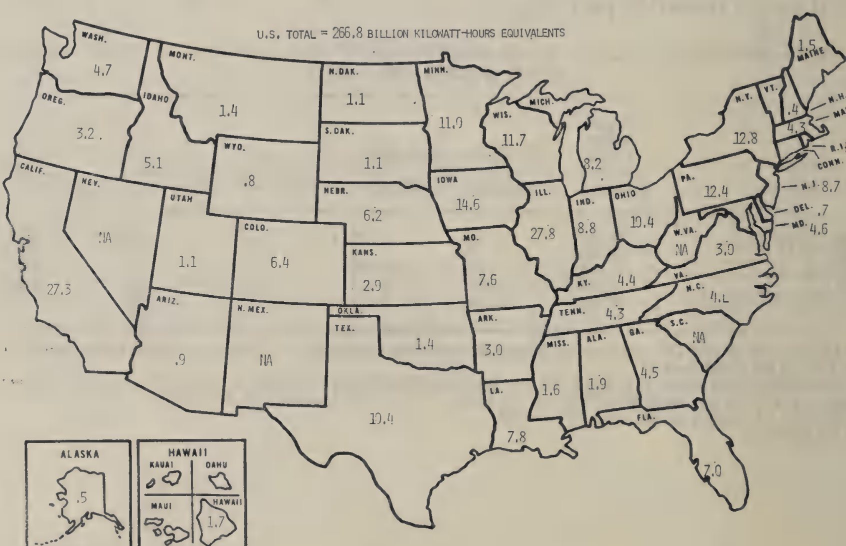
1 Includes the amount of electric energy purchased from other companies and amount of electric energy generated and used by the establishment.
2 Distillate includes grades 1, 2, and 4 fuel oil; light diesel-type fuel oil; light gas-enrichment oil. Residual includes grades 5 and 6 fuel oil; heavy diesel-type fuel oil; bunker "C" fuel oil; heavy gas-enrichment oil.
3 Includes bituminous, lignite, and anthracite coal.
4 Not available.

TABLE 48.—ENERGY USE AND VALUE ADDED BY MANUFACTURE, MAJOR FOOD PROCESSING INDUSTRIES, SELECTED PERIODS[1]

| Industry | SIC code | Energy used (billion Btu) 1954 | 1967 | 1971 | 1980 |
|---|---|---|---|---|---|
| Meatpacking | 2011 | 93, 596 | 78, 929 | 120, 170 | 137, 923 |
| Sausage and other prepared meat | 2013 | 10, 557 | 16, 101 | 22, 820 | 25, 864 |
| Dairy products | 202 | 193, 432 | 218, 703 | 241, 904 | 248, 041 |
| Canned fruits and vegetables | 2033 | 37, 268 | 36, 516 | 58, 747 | 72, 880 |
| Frozen fruits and vegetables [2] | 2037 | 8, 202 | 21, 340 | 48, 315 | 83, 658 |
| Wet corn milling | 2046 | 50, 288 | 60, 442 | 75, 075 | 96, 061 |
| Cane sugar refining | 2062 | 33, 149 | 31, 254 | 47, 486 | 48, 624 |
| Beet sugar refining | 2063 | 39, 277 | 72, 407 | 74, 597 | 89, 749 |
| Malt beverages | 2082 | 41, 502 | 40, 649 | 68, 700 | 97, 750 |
| Total | | 507, 271 | 576, 341 | 757, 814 | 900, 550 |

| Industry | SIC code | Value added by manufacture 1954 | 1967 | 1971 |
|---|---|---|---|---|
| Meatpacking | 2011 | 1, 397 | 2, 220 | 3, 042 |
| Sausage and other prepared meat | 2013 | 378 | 742 | 1, 045 |
| Dairy products | 202 | 2, 867 | 3, 446 | 3, 909 |
| Canned fruits and vegetables | 2033 | 850 | 1, 413 | 1, 528 |
| Frozen fruits and vegetables [2] | 2037 | 171 | 759 | 1, 237 |
| Wet corn milling | 2046 | 179 | 354 | 328 |
| Cane sugar refining | 2062 | 133 | 308 | 365 |
| Beet sugar refining | 2063 | 114 | 210 | 309 |
| Malt beverages | 2082 | 1, 106 | 1, 546 | 2, 177 |
| Total (current dollars) | | 7, 195 | 10, 998 | 13, 940 |
| Total (constant dollars) [3] | | 8, 093 | 10, 998 | 12, 196 |
| Btu per dollar value added [3] | | 62, 680 | 52, 404 | 62, 136 |

[1] Census of Manufactures, 1954, 1967, 1971.
[2] Includes frozen specialties (SIC 2038).
[3] Adjusted, using Processed Food and Feed Wholesale Price Index, 1967=100.




KILOWATT-HOURS EQUIVALENT (BILLIONS) OF PURCHASED FUELS USED FOR HEAT AND POWER IN THE FOOD AND KINDRED PRODUCTS GROUP, BY STATE, 1971

NA = NOT AVAILABLE

FIGURE 6

Illinois food processors consumed the most fuels, 27.8 billion kilowatt-hours equivalent for heat and power in 1971, followed by California at 27.3 billion kilowatt-hours equivalent (fig. 6). These 2 States plus Iowa, New York, Pennsylvania, Wisconsin, Minnesota, and Texas accounted for 48 percent of the purchased fuels used for heat and power.

## Fuel Used in Selected Food Processing Industries [4]

Within the food and kindred products group individual industries vary considerably in the amount of heat and power needed in the processing activity. The 16 industries in this study were selected based on the quantity of energy they used for heat and power and the availability of data on their energy requirements per unit of production. The base year of the study was 1971 and estimates were made of the amount of energy needed for heat and power in 1980.[5] In developing these estimates, it was assumed that energy per unit of production in the processing activity would be the same as in 1971. Energy needs may be overstated for 1980; technology may well be developed to reduce the amount of energy needed in processing because of the increased price of fuels and electric energy. However, counterbalancing forces exist. The thrust for clean air and water may necessitate more energy to process a unit of production in 1980. For simplification in this study a constant technological state was assumed between 1971 and 1980.

Although this report includes data on the relative importance of various fuels in 1971, any attempt to determine the fuel mix in the food and kindred products group in 1980 would be purely speculative. A thorough industry study would be needed to estimate the shift from currently used fuels, such as electricity and natural gas, to fuel oil or coal in future years. Factors to consider include the age of present heat and power equipment, cost of converting equipment to burn other than currently used fuels, storage facilities, legislation, and the availability (especially contracts for natural gas) and relative prices of the various fuels.

Of the food and kindred product industries, these 16 selected industries accounted for 62 percent of the purchased fuels used for heat and power. They accounted for 56 percent of the value added by manufacturing and 47 percent of the employment [12]. Natural gas was the major energy source (table 49).

Two of the industry groups reported—prepared feeds and feed ingredients (2042) and animal and marine fats and oils (2094)—are primarily agricultural input industries associated with feeding livestock. Fuel needs for these industries are reported in the Input Industry Section.

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[4] A direct comparison cannot be made between the energy requirements developed in this section and
those discussed in the previous section. Information presented in the previous section was obtained from
U.S. Department of Commerce, Bureau of Census publications. The data were collected by survey ques-
tionnaire from manufacturers. Establishments are classified by industry according to their primary activity.
Therefore, an establishment with a minor food processing activity (and some other primary activity) would
not be included in the food processing data.
Data developed in this section were synthesized using estimated production data for each product and
average Btu requirements for heat and power. Therefore, these estimates are more inclusive and will result
in higher energy needs for an industry than those published by the Bureau of Census.
[5] Data for the study came from several sources including published and unpublished per capita consump-
tion data from the U.S. Department of Agriculture; data on energy for heat and power from the Census of
Manufactures, U.S. Department of Commerce; discussions with industry representatives; and Btu of energy
needed to process a unit of production from a Federal Energy Office report prepared by Development
Planning and Research Associates, Inc., Manhattan, Kans.

*Meatpacking Plants (SIC 2011)*

The meatpacking industry includes establishments engaged in the slaughter of cattle, hogs, sheep, lambs, and calves. The meat is either sold or used on the premises in canning and curing, and in making sausage, lard and other products. The amount of energy needed for heat and power depends on the amount of processing done at the plant.

The Btu requirements for beef per pound of live weight slaughtered vary from 750 for slaughter with byproduct processing to 1,130 for slaughter, rendering, and primal cutting to 1,500 for slaughter, rendering and boxing. The average Btu requirement for beef processing was assumed as 1,127 per pound of live weight. For hogs, the Btu requirement per pound of live weight slaughtered varies from 1,400 for kill and chill plants to 1,900 for plants selling primal cuts [20].

TABLE 49.—ENERGY USE PATTERNS BY TYPE OF ENERGY IN 1971 FOR INDUSTRIES STUDIED

[In percent]

| SIC No. and industry | | Propane | Middle distillates | Residual fuel oils | Other petroleum products [1] | Coal | Natural gas | Purchased electricity | Total |
|---|---|---|---|---|---|---|---|---|---|
| 2011 | Meat packing | 2.1 | 3.3 | 5.2 | 0.2 | 10.1 | 48.8 | 30.5 | 100 |
| 2013 | Sausage and processed meat | 1.2 | 8.1 | 3.7 | .2 | .9 | 48.4 | 37.6 | 100 |
| 2026 | Fluid milk | 1.8 | 8.1 | 4.1 | 2.1 | 3.3 | 34.9 | 45.8 | 100 |
| 2033 | Cannel fruits and vegetables | 2.9 | .9 | 6.8 | (3) | 3.4 | 69.6 | 16.4 | 100 |
| 2037 | Frozen fruits and vegetables [2] | 1.0 | .5 | 2.8 | (3) | 3.6 | 42.1 | 50.2 | 100 |
| 2042 | Prepared animal feeds | 3.0 | 3.5 | 2.4 | 1.1 | .3 | 53.4 | 36.5 | 100 |
| 2046 | Wet corn milling | .1 | 4.5 | 1.3 | (3) | 35.6 | 44.2 | 14.1 | 100 |
| 2062 | Cane sugar refining | (3) | .2 | 30.2 | (3) | 0 | 68.9 | .6 | 100 |
| 2063 | Beet sugar processing [4] | (3) | .1 | 2.4 | (3) | 25.8 | 66.4 | 1.4 | 100 |
| 2082 | Malt beverage | .7 | 5.3 | 11.5 | (3) | 7.0 | 38.3 | 37.3 | 100 |
| 2094 | Animal and marine fats and oils | .8 | 6.6 | 9.1 | .7 | .8 | 65.9 | 15.9 | 100 |

[1] Lubricants and gasoline.
[2] Includes frozen specialties (SIC 2038).
[3] Not reported.
[4] Coke accounted for 4 percent of the total.

Source: Industrial Energy Study of Selected Food Industries, Development Planning and Research Associates, Inc., P.O. Box 727, Manhattan, Kans., March 1974.

TABLE 50.—BTU FOR HEAT AND POWER FOR SELECTED INDUSTRIES IN THE FOOD AND KINDRED PRODUCTS INDUSTRY, 1971 AND 1980

| Industry | SIC Code | Quantity form | 1971 | | 1980[1] | |
|---|---|---|---|---|---|---|
| | | | Unit, million pounds | Billion Btu | Unit, million pounds | Billion Btu |
| Meat packing: | 2011 | | | | | |
| Beef | | Live weight | 37,713 | 42,503 | 47.037 | 53,011 |
| Pork | | Live weight | 22,780 | 37,587 | 23,628 | 38,987 |
| Processing of sausage and meats. | | Final product | 6,000 | 40,080 | 6,875 | 45,925 |
| Total | | | | 120,170 | | 137,923 |
| Sausage and other prepared meats | 2013 | Final product | 5,600 | 22,820 | 6,347 | 25,864 |
| Dairy products: | | | | | | |
| Fluid milk, packaged and bulk. | 2026 | Fresh equivalent | 56,541 | 16,962 | 53,175 | 15,952 |
| Creamery butter | 2021 | Fresh equivalent | | | | |
| Cheese, natural and processed. | 2022 | Fresh equivalent | | | | |
| Condensed and evaporated milk. | 2023 | Fresh equivalent | | | | |
| Ice cream and frozen desserts | 2024 | Fresh equivalent | 63,759 | 224,942 | 65,785 | 232,089 |
| Total | | | | 241,904 | | 248,041 |
| | | | 1,000 tons | Billion Btu | 1,000 tons | Billion Btu |
| Canned fruits and vegetables: | 2033 | | | | | |
| Fruits | | Fresh equivalent | 6,193 | 22,295 | 7,913 | 28,487 |
| Vegetables, excluding tomatoes. | | Fresh equivalent | 4,504 | 19,367 | 5,486 | 23,590 |
| Tomatoes | | Fresh equivalent | 5,339 | 17,085 | 6,501 | 20,803 |
| Total | | | | 58,747 | | 72,880 |
| | | | Million pounds | Billion Btu | Million pounds | Billion Btu |
| Frozen fruits and vegetables: | 2037 | | | | | |
| Fruits, noncitrus | | Fresh equivalent | 735 | 2,218 | 959 | 2,476 |
| Citrus concentrates | | Fresh equivalent | 7,957 | 7,856 | 10,425 | 10,294 |
| Vegetables, excluding potatoes. | | Fresh equivalent | 4,405 | 8,107 | 6,042 | 11,120 |
| Potatoes | | Fresh equivalent | 6,018 | 2,600 | 10,945 | 4,728 |
| Total | | | | 20,781 | | 28,618 |
| Frozen specialties | 2038 | Final product | 3,224 | 27,534 | 6,445 | 55,040 |
| | | | 1,000 tons | Billion Btu | 1,000 tons | Billion Btu |
| Sugar refining: | | | | | | |
| Cane sugar | 2062 | 96° sugar | 8,350 | 47,486 | 8,550 | 48,624 |
| Beet sugar | 2063 | Whole beet | 25,626 | 74,597 | 30,831 | 89,749 |
| Total | | | | 122,083 | | 138,373 |
| | | | Million bushels | Billion Btu | Million bushels | Billion Btu |
| Wet corn milling | 2046 | Bushels corn | 254 | 75,075 | 325 | 96,061 |
| | | | Million barrels | Billion Btu | Million barrels | Billion Btu |
| Malt beverage | 2082 | | | | | |
| Malt beverage | | Final product | 137.4 | 52,075 | 195.5 | 74,094 |
| Spent grain | | Final product | | 16,625 | | 23,656 |
| Total | | | | 68,700 | | 97.750 |
| Total, selected industries | | | | 757,814 | | 900,550 |

[1] Estimated by ERS, USDA.

Some plants process the meat further by smoking, preparing suasage, or canning. The Btu requirement varies from 1,500 Btu for fresh sausage to 12,000 per pound of finished product for dry and semidried sausage. The average energy requirement was assumed to be 6,680 Btu per pound of finished product.

Beef and veal slaughter on a live weight basis was estimated at 37.7 billion pounds in 1971 with 42.5 trillion Btu needed for heat and power in processing (table 50). By 1980, it is projected that energy needs will increase 25 percent to 53.0 trillion Btu to process 47 billion pounds (live weight) of beef and veal.

In 1971, natural gas accounted for about 50 percent of the energy needed for heat and power, followed by electricity at 30 percent. Coal accounted for about 10 percent of the energy requirements. Reportedly, many plants which have relied on natural gas have been informed that they must be prepared to use other fuels by 1978 [20]. This will probably result in a shift to distillate and residual fuel oils.

The per capita consumption of pork is not expected to change much so the increase in energy requirements for pork by 1980 is rather small, 1.4 trillion Btu—4 percent.

It was estimated that the meat packing industry processed 6 billion pounds of meat in 1971. Products processed include smoked or cooked pork, sausages, and cured meats. By 1980, the amount of meat processed in this industry is expected to grow to 6.9 billion pounds; energy requirements are estimated to increase 5.8 trillion Btu—15 percent.

*Sausage and other prepared meat products (SIC 2013)*

The sausage and prepared meat products industry includes establishments that process sausages, cured meats, smoked meats, canned and frozen meats, and meat specialties. The Btu requirements per pound of finished product vary: 12,000 Btu for dry and semidried sausage; 10,000 Btu for smoked and cooked pork; 4,500 Btu for canned meats; 3,200 Btu for luncheon meats and frankfurters; and 1,500 Btu for fresh sausage. Because plants do not generally specialize in one product average Btu per pound of final product was assumed as 4,075 [20].

This industry depends heavily on natural gas (48 percent) and purchased electricity (38 percent) for heat and power. Fuel oils accounted for 12 percent of the energy requirements in 1971; coal was 1 percent.

In 1971, 5.6 billion pounds of meat (final product) were processed and projected to 6.3 billion pounds of final product in 1980. Energy requirements for the industry are expected to increase from 22.8 trillion Btu in 1971 to 25.9 trillion Btu in 1980—14 percent.

*Dairy products (SIC 202)*

This industry group includes five 4-digit SIC industries: creamery butter; cheese, natural and processed; condensed and evaporated milk; ice cream and frozen desserts; and fluid milk. In estimating the energy requirements for the dairy products group, total milk production (fresh equivalent) was divided between the fluid milk industry and the other four industries because of the difference in degree of processing. The amount of energy per pound of fresh milk equivalent for bulk and packaged fluid milk was 300 Btu per pound.

Energy requirements for products in the other four industries vary considerably but were assumed to average 3,528 Btu per pound of fresh milk equivalent.

Natural gas and electricity are important sources of heat and power in the dairy products group. Of the purchased fuels (electricity not included) used for heat and power in 1971, natural gas accounted for 61 percent of the total. Data on the amount of purchased electricity is available for only the fluid milk industry (SIC 2026). Here, electricity accounted for 46 percent of the energy requirements and natural gas, 35 percent.

In 1980, 119 billion pounds of milk (fresh equivalent) will be consumed, a decrease of 1.3 billion pounds from 1971. Fluid milk use is expected to decline 3.3 billion pounds between 1971 and 1980, while the amount of milk used for cheese, butter, ice cream, and frozen desserts should increase by 2 billion pounds. For the dairy products industry group, energy requirements will be up 6.1 trillion Btu or 2.5 percent by 1980. Those for the fluid milk industry will decline 6 percent while requirements for the other four industries will rise 3 percent.

*Canned fruits and vegetables (SIC 2033)*

This industry includes establishments engaged in canning fruits and vegetables, juices, catsup and tomato sauces, preserves, jams and jellies. Production was subdivided based on the amount of energy needed in processing. The energy requirements, based on a ton of raw product processed, were assumed at 3.6 million Btu for fruits, 4.3 million Btu for vegetables, and 3.2 million Btu for tomatoes [20].

Natural gas was the most important fuel used for heat and power in canning fruits and vegetables in 1971. Electricity was second at 16 percent, followed by fuel oils at 8 percent of the total.

Total fuel for heat and power used in the canned fruits and vegetables industry is projected to reach 72.9 trillion Btu in 1980—up 24 percent. Canned fruits are estimated to account for 39 percent of energy requirements of the industry in 1980. Canned vegetables and tomatoes will need 32 percent and 29 percent, respectively.

*Frozen fruits and vegetables (SIC 2037)*

Establishments in this industry are engaged in freezing fruits, fruit juices, and vegetables.

For this energy analysis the industry was divided into four parts. The Btu requirements per 1,000 pounds of pack are as follows: frozen fruits, noncitrus, 3.02 million; frozen citrus concentrate, 6.06 million; frozen vegetables, excluding potatoes, 3.00 million; and frozen potatoes, 1.08 million [20].

Electricity accounted for 50 percent of the heat and power requirements in the frozen fruits and vegetables industry in 1971, followed by natural gas at 42 percent. The energy requirements for heat and power are projected to increase 38 percent from 20.8 trillion Btu in 1971 to 28.6 trillion Btu in 1980.

*Frozen specialties (SIC 2038)*

Frozen specialties include such products as frozen TV dinners, pies, pizza, and snack items. Btu requirements per 1,000 pounds are estimated at 8.54 million [20]. Frozen specialty products have been

increasing phenomenally in the past decade. Growth should double by 1980 as will energy requirements to about twice the energy needed by the frozen fruits and vegetable industry; 55 trillion Btu as compared with 28.6 trillion Btu, respectively.

*Sugar refining (SIC 2062 and 2063)*

The sugar cane refining industry contains establishments that process raw cane sugar and sugar syrup. Crushing the cane and manufacturing the raw sugar requires considerable energy, these activities are included in another industry (SIC 2061) and are not included in this report. The sugar beet refining industry contains establishments that manufacture sugar from sugar beets. In the processing of sugar beets, the entire activity—from slicing the beets to the final product—is carried out at the same plant.

The Btu requirements were assumed to be 5.69 million Btu per ton of raw sugar (96°) for sugar cane refining plants and 2.91 million Btu per ton of sliced raw beets [20].

Natural gas accounted for 69 percent of the heat and power requirements in sugar cane refining and 66 percent in sugar beet refining. The second most important fuel in sugar cane refining was residual fuel oil (30 percent), while in sugar beet refining it was coal (26 percent) in 1971.

In 1971, 72 percent of the refined sugar processed came from cane and 28 percent from beets. However, 61 percent of the heat and power requirements were used by the sugar beet refining industry and only 39 percent by cane sugar refining industry. Its low ratio of heat and power to final product occurs because the energy used in sugar cane milling and manufacturing of raw sugar is not reported here. Further, about 65 percent of the raw sugar processed by the industry is imported.

Heat and power energy requirements for manufacturing cane and beet sugar will increase from 122.1 trillion Btu in 1971 to an estimated 138.4 trillion Btu in 1980—13 percent. By 1980, requirements for beet sugar refining will increase 20 percent, for sugar cane refining only 2 percent.

*Wet corn milling (SIC 2046)*

Establishments in this industry mill corn and grain sorghum by the wet process. Products manufactured include starch, syrup, oil, sugar, gluten feed, and meal.

The industry produces over 500 end-use products. Plants differ on the Btu requirements per bushel of corn processed because of product mix and the particular production process used. However, for this study, the average requirement per bushel of corn processed was assumed to be 300,000 Btu. A considerable part of the Btu requirement is for heat in the evaporation and extraction activities [20].

Natural gas (44 percent) was the most important fuel used for heat and power, followed by coal at 36 percent and purchased electricity at 14 percent.

Corn processed by the industry will increase 71 million bushels by 1980. Energy requirements will rise 28 percent, from 75 trillion Btu in 1971 to 96 trillion Btu in 1980.

*Malt beverages (SIC 2082)*

This industry contains establishments that manufacture all kinds of malt beverages, such as beer, ale, malt liquors, porter, and stout.

Lager beer accounts for about 90 percent of the output and average energy requirements for heat and power are 500,000 Btu per barrel. Of this total, 379,000 Btu are needed to produce malt beverage and 121,000 Btu per barrel are needed to dry the spent grain [20]. Natural gas and electricity accounted for 38 percent and 37 percent, respectively, of the energy requirements for heat and power in 1971.

Production in the industry will increase from 137.4 million barrels in 1971 to 195.5 million barrels in 1980—42 percent. Energy requirements for heat and power will go from 68.7 trillion Btu in 1971 to 97.8 trillion Btu in 1980.

*Outlook for 1980*

Natural gas and electricity are the primary fuels in food processing Energy requirements for heat and power for the selected food and kindred products industries will increase 19 percent from 1971 to 1980. The only industry registering a decline is the fluid milk industry where production is expected to be off 6 percent. The largest percentage increase is for frozen specialities; doubling energy needs by 1980.

Energy data for the 14 selected industries were used as the basis for expanding energy needs to the remaining 28 food and kindred product industries. Thus, fuel use for all food processing industries were estimated to increase from 1,303 trillion Btu in 1971 to 1,548 trillion Btu in 1980.

## MARKETING AND DISTRIBUTION

To move fresh and processed foods through the various marketing channels certain essentials are required: rapid dependable transportation; adequate common, cold and freezer storage; regional and local wholesale assembly warehouses; supermarkets and other grocery stores; and away-from-home eating places including restaurants, clubs, and institutions.

Significant amounts of energy are used at each stage of the marketing process. Over time, energy use has intensified as changes have occurred throughout the entire marketing system. A gross estimate of the energy cost for marketing and distributing food in 1973 is $1.4 billion of the $83 billion food marketing bill. Intercity transportation costs amount to 8 percent of the food marketing bill (figure 7). Part of transportation costs are for fuel, and are discussed below.

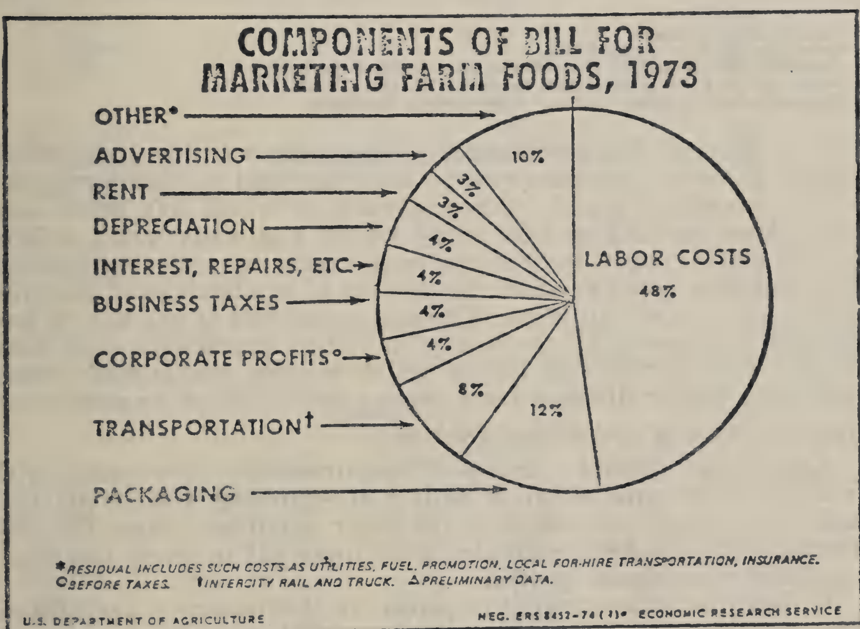


FIGURE 7

### TRANSPORTATION

The uninterrupted flow of farm inputs and products is vital to the health and welfare of farm producers, consumers, and all handlers and processors inbetween. Without an adequate transportation network, bottlenecks arise. The result is spoiled food, increased food and fiber costs to consumers, and economic losses to the industry.

Energy used to transport agricultural products and farm production inputs represents a small yet significant part of all energy used in the transportation industry. Between 1950 and 1970, transportation accounted for one-fourth of total U.S. energy consumption; the figure was 16,500 trillion Btu in 1970. Transporting farm products from the farm to the city of final consumption required 517 trillion Btu, or 3.1 percent of the total. This amount was provided by 3.4 billion gallons of diesel fuel and 376 million gallons of gasoline (table 51). When energy needs for transporting farm inputs are included, food transportation needs would probably approach 5 percent of the total.[6]

TABLE 51.—AGRICULTURAL PRODUCT TRANSPORTATION: ESTIMATED FUEL NEEDS BY MODE OF TRANSPORTATION, 1970[1]

| Mode of transportation | Tons[2] (millions) | Miles[3] | Ton miles (millions) | Ton miles per gallon[4] | Gallons (millions) | |
|---|---|---|---|---|---|---|
| | | | | | Diesel | Gasoline |
| Rail | 118.1 | 497 | 58,725 | 250 | 234.9 | |
| All trucks | 559.4 | 291 | 162,710 | 48 | 3,028.5 | 376.1 |
| Commercial | 266.8 | 568 | 151,426 | 50 | 3,028.5 | |
| Farm | 292.6 | 39 | 11,284 | [5] 30 | | 376.1 |
| Water | 34.6 | 870 | 30,090 | 220 | 136.8 | |
| All modes | 712.1 | 353 | 251,525 | 67 | 3,400.2 | 376.1 |

[1] Excludes Alaska and Hawaii.
[2] From USDA staff paper, October 2, 1970.
[3] Estimates largely from Ed Heitz, Traffic Manager, Agricultural Marketing Service.
[4] From Lincoln, G. A., Energy Conservation, Science, Vol. 180, April 13, 1973.
[5] Estimated in Economic Research Service, U.S. Department of Agriculture.

Most intracity food movements to large grocery outlets are by diesel trucks. However, gasoline-powered units are used to distribute some widely advertised brands of goods, such as bread, soft drinks and milk. Also, gasoline powers many trucks and vans which deliver food to smaller convenience stores, restaurants, and other institutions. The consumer uses a considerable amount of gasoline to buy groceries and to eat away from home. The amount of fuel is not known and difficult to estimate. Of the nearly 70 million households, most have diverse food purchasing habits which require considerably more data than simply distance from nearest grocery store or restaurant.

*Transportation of agricultural products*

Agricultural product transport requirements have risen with increased farm production to satisfy the growing U.S. population and U.S. exports to customers in other countries. Since the mid 1940's, there has been a decided shift from rail to truck transport, one largely completed by 1965.

In that year, trucks moved 78 percent of the tonnage of agricultural products. However, because products moved longer distances by rail and barge, the ton miles trucked were only 65 percent of the total (table 52). By 1970, truck tonnage had risen slightly at the expense of rail, but ton miles stayed about the same.

By 1980, trucks will account for 80 percent of the tons and 65 percent of the ton miles moved over the highways. Barges will continue to move about 5 percent of the tonnage and 12 percent of the ton miles.

[6] These data did not include the energy requirements for shipments from local or regional food warehouses to grocery stores and supermarkets. Such information is not available. However, it is known that many supermarkets are serviced daily from regional or local distribution centers. Most stores have only limited warehousing; thus, curtailed deliveries of two or three days could result in some empty food shelves.

Farm trucks in 1970 hauled more tonnage than any other carrier—41 percent, but they moved the products relatively short distances. Hence, the ton miles of product hauled were less than 5 percent. Farm trucks were used chiefly to haul small grains, hay, and sugar crops from the farm to grain elevators, hay processors and sugar plants.

Commercial trucks accounted for 60 percent of the ton miles that agricultural products travelled in 1970, a proportion expected to remain about constant through 1980. These trucks hauled a wide variety of products, including most of the perishables (table 53).

TABLE 52.—AGRICULTURAL PRODUCT TRANSPORTATION: ESTIMATED PROPORTIONS MOVED BY MODE, SELECTED YEARS, 1965–80

[In percent]

| Mode | Tons moved | Ton miles travelled |
|---|---|---|
| 1965 | | |
| Rail | 17.1 | 23.0 |
| All truck | 78.0 | 65.1 |
| Commercial | 38.6 | 60.1 |
| Farm | 39.4 | 4.0 |
| Water | 4.9 | 11.9 |
| 1970 | | |
| Rail | 16.6 | 23.3 |
| All truck | 78.6 | 64.7 |
| Commercial | 37.5 | 60.2 |
| Farm | 41.1 | 4.5 |
| Water | 4.8 | 12.0 |
| 1975 | | |
| Rail | 16.1 | 23.1 |
| Truck | 79.1 | 65.0 |
| Commercial | 37.8 | 60.5 |
| Farm | 41.3 | 4.5 |
| Water | 4.8 | 11.9 |
| 1980 | | |
| Rail | 15.7 | 23.2 |
| Truck | 79.6 | 65.0 |
| Commercial | 36.6 | 60.2 |
| Farm | 43.0 | 4.8 |
| Water | 4.7 | 11.8 |

TABLE 53.—AGRICULTURAL PRODUCT TRANSPORTATION: TONNAGE AND ESTIMATED TON MILES BY TRUCK, 1970 [1]

| Commodity | Commercial trucks | | | Farm trucks | | |
|---|---|---|---|---|---|---|
| | Tons (millions) | Miles | Ton miles (millions) | Tons (millions) | Miles | Ton miles (millions) |
| Livestock | 44.3 | 500 | 22,150 | | | |
| Poultry and eggs | 14.6 | 1,200 | 17,520 | | | |
| Milk | 73.3 | 500 | 36,650 | | | |
| Feed grains | 55.7 | 200 | 11,140 | 106.1 | 30 | 3,183 |
| Food grains | 9.7 | 200 | 1,940 | 42.1 | 40 | 1,684 |
| Soybeans | 25.0 | 200 | 5,000 | 33.3 | 30 | 999 |
| Peanuts | 2.8 | 1,000 | 2,800 | 1.4 | 25 | 35 |
| Tobacco | 2.1 | 1,100 | 2,310 | .9 | 20 | 18 |
| Fruits | 5.3 | 2,000 | 10,600 | 12.4 | 30 | 372 |
| Vegetables | 15.6 | 2,000 | 31,200 | 16.5 | 50 | 825 |
| Hay | 2.2 | 180 | 396 | 21.7 | 100 | 2,170 |
| Sugar | 12.4 | 600 | 7,440 | 50.4 | 35 | 1,764 |
| Cotton | 3.8 | 600 | 2,280 | 7.8 | 30 | 234 |
| Total | 266.8 | 568 | 151,426 | 292.6 | 39 | 11,284 |

[1] See footnotes to table 51.

TABLE 54.—AGRICULTURAL PRODUCTS TRANSPORTED BY MODE OF TRANSPORTATION, 1970[1]

| Commodity | Rail: Tons (millions) | Rail: Miles[3] | Rail: Ton miles (millions) | All trucks[2]: Tons (millions) | All trucks[2]: Miles | All trucks[2]: Ton miles (millions) | Water: Tons (millions) | Water: Miles | Water: Ton miles (millions) | All modes: Tons (millions) | All modes: Miles | All modes: Ton miles (millions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Livestock | 1.8 | 1,000 | 1,800 | 44.3 | 500 | 22,150 | | | | 46.1 | 520 | 23,950 |
| Poultry and eggs | | | | 14.6 | 1,200 | 17,520 | | | | 14.6 | 1,200 | 17,520 |
| Milk | | | | 73.3 | [4] 500 | 36,650 | | | | 73.3 | [4] 500 | 36,650 |
| Feed grains | 23.0 | 386 | 8,878 | 161.8 | 88 | 14,323 | 9.7 | 800 | 7,760 | 194.5 | 159 | 30,961 |
| Food grains | 38.0 | 386 | 14,668 | 51.8 | 70 | 3,624 | 12.4 | 1,100 | 13,640 | 102.2 | 312 | 31,932 |
| Soybeans | 27.0 | 172 | 4,644 | 58.3 | 103 | 5,999 | 12.2 | 700 | 8,540 | 97.5 | 197 | 19,183 |
| Peanuts | .3 | 800 | 240 | 4.2 | 675 | 2,835 | | | | 4.5 | 683 | 3,075 |
| Tobacco | 1.9 | 803 | 1,526 | 3.0 | 776 | 2,328 | | | | 4.9 | 787 | 3,854 |
| Fruits | 1.2 | 2,025 | 2,430 | 17.7 | 620 | 10,972 | .3 | 500 | 150 | 19.2 | 706 | 13,552 |
| Vegetables | 5.7 | 2,021 | 11,520 | 32.1 | 998 | 32,025 | | | | 37.8 | 1,152 | 43,545 |
| Hay | .2 | 1,000 | 200 | 23.9 | 107 | 2,566 | | | | 24.1 | 115 | 2,766 |
| Sugar | 12.5 | 636 | 7,950 | 62.8 | 147 | 9,204 | | | | 75.3 | 228 | 17,154 |
| Cotton | 6.5 | 749 | 4,869 | 11.6 | 218 | 2,514 | | | | 18.1 | 408 | 7,383 |
| Total | 118.1 | 497 | 58,725 | 559.4 | 291 | 162,710 | 34.6 | 870 | 30,090 | 712.1 | 353 | 251,525 |

[1] Based on USDA staff paper, Projected Agricultural Transportation Requirements, Oct. 2, 1970; and USDA staff paper, Projected Agricultural Transportation Requirements—Modal Distribution Oct. 30, 1970; and estimates on mileage by commodity by mode of travel by Ed Heitz, Traffic Manager Agricultural Marketing Service, June 8, 1973. Excludes Alaska and Hawaii.

[2] Includes farmer-owned trucking and commercial trucking from table 53.

[3] From DOT, Statement TD–1, Year 1969, Carload Waybill Statistics, 1969, Office of Systems Analysis and Information, U.S. DOT, Washington, D.C.

[4] Includes mileage for trucks returning empty.

Trains carried mainly nonperishable items, including grain crops, sugar and cotton, although significant amounts of fruits and vegetables move cross country by rail (table 54). Barge traffic was virtually all grain and soybeans.

The distances commodities are shipped indicate the proximity of production to consumption or export locations. Broiler production is mainly located in the Southeast and South Central States, far from population centers. Hence, poultry products moved an average of 1200 miles. Fruit and vegetable production in California, Florida, and Texas is across the country from major consumption centers, but significant local production of fruits and vegetables still occurs near these centers. As a result, the average mileage traveled is less than for poultry. Feed grains and hay, which are fed to animals in relatively nearby feedlots, traveled less than 200 miles. Food grains moving by barge went from the midwest to export ports on the Gulf Coast.

Though trucks accounted for 79 percent of the ton miles of agricultural products, they burned 90 percent of the diesel and gasoline used for such purposes in 1970 (table 51). Trucks averaged about 48 ton miles per gallon; they are much less energy efficient than rail or water traffic, estimated to average 250 and 220 ton miles per gallon, respectively. Farm trucks are the least energy efficient form of truck transport because of their small size and carrying capacity, their almost complete reliance on gasoline engines, and less favorable road conditions.

The extensive use of trucks to move agricultural products results from several factors. First, farms, widely dispersed across rural America, must rely on roads to move their products because rail and water transportation are simply not available at the farm level. Second, timeliness is essential for moving many perishable products (1) to retail outlets so that consumers will have fresh milk, meat, fruits and vegetables; and (2) to processing plants for conversion to forms that can be stored for off-season use. Rail and water traffic is generally too slow and often less dependable in meeting schedules. Third, trucks are flexible; alterations in timing, pickup point, or final destination of products are possible without seriously impairing delivery schedules.

Finally, until the recent imposition of reduced speed limits, availability of trucks to move agricultural products has generally been good. Rural roads and interstate highways have been greatly improved in the past decade, which has permitted prompt, safe delivery of farm products by truck. However, the maximum speed limit for trucks is now 55 miles per hour (mph) on most highways, as compared with limits up to 75 mph in some States in 1973. The reduced speed limit causes longer turn-around times for truckers.

The long-haul truckers, such as those hauling perishable fruits and vegetables across country, are more adversely affected than the short-haul truckers.

Long-haul drivers can achieve higher average speeds since they experience limited through-town driving and use interstate highways. At the 55 mph speed limit long-haul truckers would reduce average speeds 17 percent, which translates into nearly a 17-percent reduction in truck availability to the food and fiber sector for long-distance hauling.[7]

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[7] To the extent that speed limits are not observed and truckers drive longer hours, the impact on truck availability will be less than indicated above.

The lower speed limit reduces short-haul truck speeds 12 percent. A similar reduction would probably not occur in trucking capacity. Many short-haul trucks are operated part-time, and drivers can compensate for the lower speeds by driving longer.

Changes in rail transportation have affected rural areas: branch line terminations as well as insufficient numbers of clean and adequate rolling stock—both refrigerated cars for perishables and common box cars for hauling grain, soybeans and hay. As U.S. export volume has increased in recent years severe box car shortages have occurred. These have impeded delivery schedules of grain and more importantly, denied rolling stock for other freight, including agricultural inputs (fertilizer and feed grains) and farm production.

*Transportation of selected agricultural inputs*

Though energy use data for agricultural inputs are incomplete, figures are given, where possible for estimated tonnage, ton mileage, and fuel use.

Major farm inputs requiring substantial transportation include feed, fertilizer, farm machinery, fuel, other agricultural chemicals and seed.

Trucks, rail and water are again the primary modes of movement; however, pipelines are used for interstate transport of fuels and anhydrous ammonia fertilizer.

*Feed.*—Of the 68.5 millions tons of primary formula feed [8] ingredients transported in 1969, 47 percent were feed grains. They accounted for 52 percent of the 22.7 million ton miles required to move ingredients for manufacturing primary formula feed (table 55) [34].

The volume of ingredients of primary feeds was greatest in the Corn Belt where major quantities of grains and soybeans are produced and significant livestock production is located. However, because of the comparatively short distance that feed is hauled there, the Pacific, Northeast, Southeast and Appalachian Regions had greater ton mileages for feed ingredients.

Manufacturers of both primary and secondary feeds [9] procured most of their ingredients by truck—55 percent of 101 million tons (table 56). The proportion varied by region; rail moved about two-thirds of the supplies in the Appalachian, Southeast and Delta States.

Transporting formula feeds from the manufacturing plant to the farm was done mainly by truck. This mode moved 89 percent of the manufactured feed (table 57). Feed moved an average of less than 60 miles after manufacture compared with 330 miles for its ingredients. Distributing this input to farmers required moving feed 5.6 billion ton miles.

*Fertilizer.*—Current information on fuel requirements and the distribution and marketing of agricultural fertilizer is not available. But data on modes of transportation from the 1967 Census of Transportation are considered to be applicable. In that year, 35,738,000 tons of agricultural fertilizers were shipped domestically.

The modes of transportation used were as follows:

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[8] Primary feed manufacturing is processing and mixing individual feed ingredients, sometimes with the addition of a premix at a rate of less than 100 pounds per ton of finished feed.

[9] Secondary feed manufacturing is processing and mixing one or more ingredients with formula feed supplements.

TABLE 55.—INGREDIENTS FOR MANUFACTURE OF FORMULA FEEDS, 1969

| Region | Feed grains | | | Grain by-products | | | Oilseed meals | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tons (thousands) | Miles | Ton miles (thousands) | Tons (thousands) | Miles | Ton miles (thousands) | Tons (thousands) | Miles | Ton (thousands) |
| Northeast | 3, 701 | 363 | 1, 343, 463 | 2, 382 | 593 | 1, 412, 526 | 1, 149 | 620 | 712, 380 |
| Lake States | 1, 520 | 72 | 109, 440 | 499 | 132 | 65, 868 | 973 | 133 | 129, 409 |
| Corn Belt | 4, 355 | 127 | 553, 085 | 1, 392 | 167 | 232, 464 | 3, 393 | 100 | 339, 300 |
| Northern Plains | 2, 075 | 62 | 128, 650 | 609 | 173 | 105, 357 | 898 | 212 | 190, 376 |
| Appalachian | 3, 075 | 400 | 1, 230, 000 | 667 | 385 | 256, 795 | 1, 377 | 339 | 466, 803 |
| Southeast | 4, 275 | 461 | 1, 970, 775 | 410 | 544 | 227, 140 | 1, 553 | 277 | 430, 181 |
| Delta States | 3, 153 | 399 | 1, 258, 047 | 291 | 466 | 135, 606 | 969 | 220 | 213, 180 |
| Southern Plains | 3, 719 | 273 | 1, 015, 287 | 559 | 302 | 168, 818 | 1, 150 | 351 | 403, 650 |
| Mountain | 2, 608 | 263 | 685, 904 | 209 | 182 | 38, 038 | 327 | 624 | 204, 048 |
| Pacific | 3, 852 | 894 | 3, 443, 688 | 769 | 517 | 397, 573 | 721 | 973 | 701, 533 |
| United States | 32, 333 | 363 | 11, 738, 339 | 7, 787 | 390 | 3, 040, 185 | 12, 510 | 303 | 3, 790, 860 |
| | Animal protein | | | 14 specified ingredients | | | Total | | |
| Northeast | 343 | 173 | 59, 339 | 1, 047 | 276 | 288, 630 | 8, 622 | 443 | 3, 816, 338 |
| Lake States | 325 | 136 | 44, 200 | 801 | 315 | 252, 223 | 4, 118 | 146 | 601, 140 |
| Corn Belt | 768 | 150 | 115, 200 | 2, 466 | 373 | 920, 251 | 12, 374 | 175 | 2, 160, 300 |
| Northern Plains | 169 | 133 | 22, 477 | 1, 319 | 239 | 314, 668 | 5, 070 | 150 | 761, 528 |
| Appalachian | 366 | 170 | 62, 220 | 731 | 395 | 288, 830 | 6, 216 | 371 | 2, 304, 648 |
| Southeast | 412 | 198 | 81, 576 | 1, 003 | 335 | 335, 725 | 7, 653 | 398 | 3, 045, 397 |
| Delta States | 313 | 289 | 90, 457 | 681 | 361 | 245, 981 | 5, 407 | 359 | 1, 943, 271 |
| Southern Plains | 180 | 158 | 28, 440 | 1, 648 | 261 | 430, 447 | 7, 256 | 282 | 2, 046, 642 |
| Mountain | 105 | 260 | 27, 300 | 1, 361 | 186 | 252, 909 | 4, 610 | 262 | 1, 208, 199 |
| Pacific | 307 | 120 | 36, 840 | 1, 558 | 134 | 208, 863 | 7, 207 | 664 | 4, 788, 497 |
| United States | 3, 288 | 173 | 568, 049 | 12, 616 | 280 | 3, 538, 527 | 68, 532 | 331 | 22, 675, 960 |

Source: [34]

TABLE 56.—INSHIPMENTS OF FORMULA FEED INGREDIENTS BY MODE OF TRANSPORTATION, BY REGIONS, 1969 [1]

[In thousand tons]

| Region | Rail | Trucks | Water | Total |
|---|---|---|---|---|
| Northeast | 6,453 | 3,489 | 115 | 10,057 |
| Lake States | 3,034 | 6,576 | NA | 9,610 |
| Corn Belt | 7,290 | 14,596 | 60 | 21,946 |
| Northern Plains | 2,333 | 7,221 | 40 | 9,594 |
| Appalachian | 5,175 | 2,778 | 4 | 7,957 |
| Southeast | 5,837 | 2,513 | 852 | 9,202 |
| Delta States | 4,455 | 1,663 | 3 | 6,121 |
| Southern Plains | 3,323 | 7,470 | 25 | 10,818 |
| Mountain | 2,007 | 4,963 | 7 | 6,977 |
| Pacific | 4,095 | 4,628 | 9 | 8,732 |
| 47 States [2] | 44,002 | 55,897 | 1,115 | 101,014 |

[1] Includes ingredients for both primary and secondary manufactured feeds in establishments producing 1,000 tons or more of feed.
[2] Excludes Rhode Island, Alaska, and Hawaii.

Source: [34]

TABLE 57.—REGIONAL OUTSHIPMENTS OF FORMULA FEED BY MODE OF TRANSPORTATION, 1969 [1]

| Region | Rail | | | Trucks | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1,000 tons | Miles | 1,000 ton miles | 1,000 tons | Miles | 1,000 ton miles | 1,000 tons | Miles | 1,000 ton miles |
| Northeast | 1,631 | 206 | 335,986 | 7,953 | 34 | 270,402 | 9,584 | 63 | 606,388 |
| LakeS tates | 218 | 164 | 35,752 | 8,728 | 28 | 244,384 | 8,946 | 31 | 280,136 |
| Corn Belt | 2,595 | 256 | 664,320 | 18,477 | 47 | 868,419 | 21,072 | 73 | 1,532,739 |
| Northern Plains | 730 | 195 | 142,350 | 7,934 | 46 | 364,964 | 8,664 | 59 | 507,314 |
| Appalachian | 1,371 | 167 | 228,957 | 6,346 | 38 | 241,148 | 7,717 | 61 | 470,105 |
| Southeast | 1,134 | 182 | 206,388 | 8,007 | 40 | 320,280 | 9,141 | 58 | 526,668 |
| Delta States | 752 | 156 | 117,312 | 5,362 | 33 | 176,946 | 6,114 | 48 | 294,258 |
| Southern Plains | 1,390 | 253 | 351,670 | 9,335 | 44 | 410,740 | 10,725 | 71 | 762,410 |
| Mountain | 101 | 264 | 26,664 | 6,720 | 46 | 309,120 | 6,821 | 49 | 335,784 |
| Pacific | 501 | 157 | 78,657 | 8,228 | 28 | 230,384 | 8,729 | 35 | 309,041 |
| 47 States [2] | 10,423 | 210 | 2,188,056 | 87,090 | 39 | 3,436,787 | 97,513 | 58 | 5,624,843 |

[1] Includes ingredients for both primary and secondary manufactured feeds in establishments producing 1,000 tons or more of formula feed.
[2] Excludes Rhode Island, Alaska, and Hawaii.

Source: [34]

| Mode: | *Shipments (percent)* |
|---|---|
| Rail | 47.5 |
| Motor carrier | 19.0 |
| Private truck | 23.9 |
| Barge | 9.3 |
| Other | .1 |
| Unknown | .2 |

The agricultural fertilizer manufacturing industry is fairly well dipersed among the farm production regions. Shipments of fertilizer as measured by distances travelled indicate a relatively less concentrated geographical area of production than for the farm machinery industry. For example, 25 percent of fertilizer ton miles shipped involved distances of less than 200 miles, compared with less than 10 percent of farm machinery shipments.

Transportation remains a vital ingredient; about half the ton miles were shipped distances in excess of 500 miles (table 58). Since 1980 demand for fertilizer will be 25 percent over 1972–73 and because truck transport of these materials will probably rise, fuel need will increase 30 percent or more.

*Farm machinery.*—Most farm machinery produced in the United States is manufactured or assembled in a seven or eight State area comprising parts of the Lake States, Corn Belt, and Northeast. Large numbers of machines are sold for use in these areas. Thus, the control area of equipment manufacture, assembly, and distribution appears to be reasonably efficient, point of supply is close to points of demand.

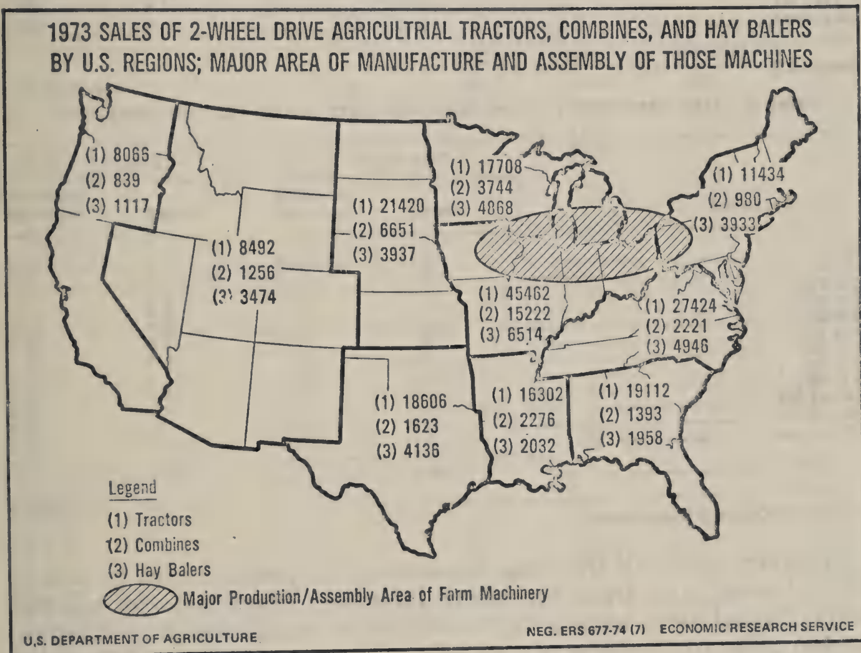


FIGURE 8

However, significant amounts of machinery move to more distant points of the country (figure 8). Almost a third of the tractors and hay balers and over half the combines purchased were sold to farmers in the Corn Belt and Lake States. The Southern Plains, Delta States, and Southeast regions accounted for almost 30 percent of tractors purchased, 15 percent of combines sold, and 22 percent of balers purchased.

Though the data are not current, the 1967 Census of Transportation provides some insight into the magnitude of transportation requirements and the mode for moving farm machinery. In 1967, over 70 percent of the machinery was shipped less than 600 miles (table 59). Conversely, only 2 percent of the machinery went 1,500 or more miles.

TABLE 58.—DISTRIBUTION OF FERTILIZER: PERCENTAGE OF TOTAL TON-MILES FROM FACTORIES, BY DISTANCE CLASSES, 1967

| Distance (miles) | Ton-miles shipped | |
|---|---|---|
| | Percent | Cumulative percentage |
| Under 50 | 2.9 | 2.9 |
| 50 to 99 | 7.6 | 10.5 |
| 100 to 199 | 14.2 | 24.7 |
| 200 to 299 | 9.5 | 34.2 |
| 300 to 399 | 10.7 | 44.9 |
| 400 to 499 | 7.6 | 52.5 |
| 500 to 599 | 3.9 | 56.4 |
| 600 to 799 | 16.0 | 72.4 |
| 800 to 999 | 12.0 | 84.4 |
| 1,000 to 1,199 | 10.3 | 94.7 |
| 1,200 to 1,499 | 4.5 | 99.2 |
| 1,500 or more | .8 | 100.0 |

Source: [13]

TABLE 59.—FARM MACHINERY: TONS AND TOTAL TON MILES SHIPPED FROM FACTORIES, 1967

| Distance (miles) | Tons shipped | | Ton-miles | |
|---|---|---|---|---|
| | Percent | Cumulative percentage | Percent | Cumulative percentage |
| Under 50 | 5.1 | 5.1 | 0.2 | 0.2 |
| 50 to 99 | 7.8 | 12.9 | 1.3 | 1.5 |
| 100 to 199 | 14.0 | 26.9 | 5.8 | 7.3 |
| 200 to 299 | 14.3 | 41.2 | 8.1 | 15.4 |
| 300 to 399 | 13.9 | 55.1 | 11.7 | 27.1 |
| 400 to 499 | 9.4 | 64.5 | 9.6 | 36.7 |
| 500 to 599 | 7.4 | 71.9 | 9.0 | 45.7 |
| 600 to 799 | 12.3 | 84.2 | 17.8 | 63.5 |
| 800 to 999 | 8.0 | 92.2 | 14.5 | 78.0 |
| 1,000 to 1,199 | 3.0 | 95.2 | 7.5 | 85.5 |
| 1,200 to 1,499 | 2.8 | 98.0 | 7.8 | 93.3 |
| 1,500 or more | 2.0 | 100.0 | 6.7 | 100.0 |
| Total | 100.0 | | 100.0 | |

Source: 1967 Census of Transportation.

However, over half the total ton-miles of shipments were to points 600 miles or more from producing factories. Allocations to specific items of machinery were not possible, but a significant proportion of the ton miles in the 600-or-more mile category could be explained by movements of high-horsepower tractors, self-propelled combines, and hay balers to the Southern Plains, Delta States, Southeast, and parts of the Appalachian areas.

In 1967, the percentage of ton-miles shipped were distributed as follows:

| | |
|---|---|
| Rail | 47.0 |
| Motor carriers | 32.2 |
| Private truck | 17.8 |
| Other and unknown | 1.0 |

Current trends in transportation of farm machinery are not known, but the proportion moved by rail is likely trending downward.

*Pesticides.*—In 1967, rails moved nearly 43 percent of the pesticide shipments on a weight basis and nearly 64 percent on a ton-mileage basis (table 60). Commercial motor carriers were in second place and private trucks (those owned by manufacturers or their customers) in third place. Based on tonnage shipped, rails have moved up from third to first in the 4 years following 1963; private trucks have dropped

from first to third. Rails usually haul longer distances; motor carriers, intermediate distances; and private trucks, shorter distances. In 1967, 39 percent of the pesticides moved 400 miles or more, up from only 24 percent in 1963 (table 61). The size of the shipments had also increased. In 1967, 66 percent of the shipments were 30,000 pounds or above, up from 48 percent in 1963.

*Petroleum products.*—In 1973, farmers used 11.4 billion gallons of refined petroleum fuel—8 billion in production operations and 3.4 billion for farmstead and family uses.

TABLE 60.—PESTICIDE SHIPMENTS: PERCENT DISTRIBUTION BY MODE OF TRANSPORT, UNITED STATES, 1963 AND 1967

[In percent]

| Mode of transport | Weight basis | | Ton mileage basis | |
|---|---|---|---|---|
| | 1963 | 1967 | 1963 | 1967 |
| Rail | 17.0 | 42.7 | 37.9 | 63.5 |
| Motor carrier | 32.1 | 32.5 | 29.4 | 25.4 |
| Private truck | 48.1 | 24.0 | 27.9 | 10.4 |
| Water | .8 | .1 | 1.0 | .3 |
| Other | 2.0 | .7 | 3.8 | .4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Bureau of the Census Reports TC63-C3-1 and TC67-C3-1, Commodity Transportation Survey.

TABLE 61.—PESTICIDE SHIPMENTS BY DISTANCE AND WEIGHT OF SHIPMENTS, UNITED STATES, 1963 AND 1967

[In percent]

| Item | Weight basis | | Weight-mileage basis | |
|---|---|---|---|---|
| | 1963 | 1967 | 1963 | 1967 |
| Miles shipped: | | | | |
| 0 to 49 | 5.5 | 14.0 | NA | 0.8 |
| 50 to 99 | 10.2 | 10.4 | NA | 1.6 |
| 100 to 199 | 28.5 | 10.9 | NA | 3.8 |
| 200 to 299 | 21.7 | 14.8 | NA | 8.0 |
| 300 to 399 | 10.5 | 10.8 | NA | 8.4 |
| 400 to 499 | 3.5 | 5.4 | NA | 5.1 |
| 500 to 599 | 4.0 | 3.4 | NA | 4.0 |
| 600 to 799 | 5.3 | 6.7 | NA | 10.5 |
| 800 to 999 | 3.5 | 11.1 | NA | 20.9 |
| 1,000 to 1,199 | 1.6 | 7.0 | NA | 16.1 |
| 1,200 to 1,499 | 2.4 | 2.0 | NA | 5.7 |
| 1,500 to 1,999 | 2.7 | 1.4 | NA | 5.2 |
| 2,000 and over | 0.6 | 2.1 | NA | 9.9 |
| Total | 100.0 | 100.0 | NA | 100.0 |
| Weight of shipment (pounds): | | | | |
| 1 to 999 | 2.8 | 2.0 | 1.9 | 1.3 |
| 1,000 to 9,999 | 25.3 | 12.7 | 15.8 | 6.6 |
| 10,000 to 29,999 | 23.4 | 19.3 | 16.7 | 13.9 |
| 30,000 to 59,999 | 32.5 | 32.7 | 36.2 | 30.9 |
| 60,000 to 89,999 | 5.9 | 17.7 | 11.2 | 28.1 |
| 90,000 and over | 10.1 | 15.6 | 18.2 | 19.2 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Bureau of the Census Reports TC63-C3-1 and TC67-C3-1, Commodity Transportation Survey.
NA—Not available.

The fuel needs of agriculture are unique—specific fuels are needed at specific times for specific purposes. Fuel must be available for planting, cultivating, harvesting and drying at specific times, but the exact times depend heavily on the weather. Use is highly seasonal

and difficult to determine accurately on a monthly basis. The equipment a farmer owns determines the fuel used; generally, no substitute can be used. The storage facilities on farms usually are limited, often to a 2 weeks supply.

Delivering petroleum fuel to farmers requires considerable transportation; distances between farms are substantial and gallons delivered per trip are limited by farm storage capacity. In 1966, the average delivery truck in Kansas traveled almost 16,000 miles to deliver 298,000 gallons of fuel or 18.7 gallons per truck-mile [38]. Some North Central States LP gas distributors indicated they averaged 112 miles per trip during January, 1969 delivering 2,083 gallons per trip or 19 gallons per truck mile. Among distributors, mileage per trip varied from 56 to 180, and gallons delivered per mile ranged from 10.8 to 35.8 gallons. It is assumed that fuel delivery trucks average 5 miles per gallon of fuel. To deliver the 11.4 billion gallons of petroleum fuel used for farm production and households in 1973 would have required 120 million gallons of fuel.

Fuel is also needed to transport petroleum products from the refinery to major bulk plants and to local distributors. Data are not available for estimates of needs.

*Transportation outlook for 1980*

Agricultural transportation requirements are expected to continue to increase over the next several years. However, many factors cloud the picture in assessing shifts in transportation modes and, hence, energy requirements for 1980.

Reorganization of railroads and possible termination of freight service to many rural communities could increase the use of trucks. Simultaneously, reduced regulation and greater competitive incentives by railroads could increase the use of rail transportation for interstate shipments of agricultural products. Certainly, energy costs and regulations such as lower highway speeds, as well as environmental considerations, will favor the use of more energy-efficient transportation modes.

Regardless of mode, agricultural marketings and, thus, transportation requirements are expected to continue expanding through 1980. Marketings in 1969–71 were estimated at 413 million tons of product expressed as final demand. By 1980, 511 million tons are projected to be marketed, a 24-percent increase over 1969–71 levels (table 62). Because of the multiple handling of many agricultural products, loadings in 1980 will reach 894 million short tons (table 63), an increase of about 25 percent. However, ton mileage will rise less rapidly; projected mileage per ton is expected to drop from 353 miles in 1970 to 336 miles in 1980.

Projected gasoline and diesel fuel use in 1980 for agricultural product transportation is expected to climb 19 percent to about 4.5 billion gallons, as compared with 3.8 billion gallons in 1970 (table 64). Gasoline use in farm truck hauling will expand to about 430 million gallons in 1980, compared with 376 million gallons in 1970. Diesel use in truck, rail, and water transportation modes will rise nearly 20 percent from 1970, totaling 4 billion gallons in 1980. Most of the increased use of diesel will come from greater truck use.

TABLE 62.—AGRICULTURAL MARKETINGS, SELECTED YEARS, 1959–61 TO 1980 [1]

[Million tons]

| Commodity [2] | 1959–61 | 1969–71 | 1972 | 1973 | 1980 |
|---|---|---|---|---|---|
| Livestock (liveweight equivalent) | 22.7 | 29.8 | 30.3 | 30.1 | 35.7 |
| Poultry and eggs | 7.6 | 9.6 | 10.0 | 10.0 | 11.5 |
| Milk | 61.8 | 58.5 | 60.2 | 59.9 | 60.6 |
| Feed grains | 87.1 | 106.6 | 117.2 | 129.6 | 150.5 |
| Food grains | 37.1 | 45.4 | 47.1 | 54.3 | 51.3 |
| Soybeans | 17.3 | 33.7 | 37.7 | 45.3 | 52.4 |
| Peanuts | .8 | 1.4 | 1.7 | 1.7 | 2.0 |
| Tobacco | 1.0 | .9 | .9 | 1.0 | 1.0 |
| Fruits (fresh equivalent) | 16.9 | 20.5 | 18.6 | 21.2 | 23.4 |
| Vegetables (fresh equivalent) | 21.7 | 23.8 | 24.5 | 24.7 | 26.5 |
| Hay | 22.0 | 24.6 | 25.2 | 25.4 | 26.9 |
| Sugar cane and beet | 33.3 | 51.5 | 54.6 | 56.2 | 61.8 |
| Cottonlint and seed | 9.6 | 6.8 | 8.4 | 8.4 | 7.7 |
| Total | 338.9 | 413.1 | 436.4 | 467.8 | 511.3 |

[1] Source: Based on internal projections of the Econ. Res. Serv., U.S. Dept. Agr.
[2] Projected production less quantities not sold off farms. Assumes all production is sold off farm except for:

| Commodity | Percent sold off farm |
|---|---|
| Food grains | 93.6 |
| Feed grains* | 58.7 |
| Soybeans | 98.1 |
| Hay | 19.1 |

*Increased ½ percent per year after 1972 to account for increasing exports.

TABLE 63.—AGRICULTURAL PRODUCTS TRANSPORTED BY MODE OF TRANSPORTATION, 1980 [1]

| Commodity | Rail | | | All truck [2] | | | Water | | | All modes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons (millions) | Miles [3] | Ton miles (millions) | Tons (millions) | Miles | Ton miles (millions) | Tons (millions) | Miles | Ton miles (millions) | Tons (millions) | Miles | Ton miles (millions) |
| Livestock | 2.5 | 1,000 | 2,500 | 60.4 | 500 | 30,200 | | | | 62.9 | 520 | 32,700 |
| Poultry and eggs | | | | 17.6 | 1,200 | 21,120 | | | | 17.6 | 1,200 | 21,120 |
| Milk | | | | 73.4 | [4] 500 | 36,700 | | | | 73.4 | [4] 500 | 36,700 |
| Feed grains | 32.6 | 386 | 12,584 | 242.1 | 85 | 20,676 | 13.8 | 800 | 11,040 | 288.5 | 154 | 44,300 |
| Food grains | 35.7 | 386 | 13,780 | 57.9 | 68 | 3,916 | 11.7 | 1,100 | 12,870 | 105.3 | 290 | 30,566 |
| Soybeans | 35.8 | 172 | 6,158 | 77.3 | 103 | 7,963 | 16.2 | 700 | 11,340 | 129.3 | 197 | 25,461 |
| Peanuts | .3 | 800 | 240 | 5.5 | 681 | 3,745 | | | | 5.8 | 687 | 3,985 |
| Tobacco | 1.6 | 803 | 1,285 | 2.7 | 780 | 2,106 | | | | 4.3 | 789 | 3,391 |
| Fruits | 1.5 | 2,025 | 3,038 | 23.7 | 620 | 14,698 | .5 | 500 | 250 | 25.7 | 700 | 17,986 |
| Vegetables | 7.1 | 2,021 | 14,349 | 37.0 | 983 | 36,365 | | | | 44.1 | 1,150 | 50,714 |
| Hay | .3 | 1,000 | 300 | 26.1 | 107 | 2,794 | | | | 26.4 | 117 | 3,094 |
| Sugar | 16.7 | 636 | 10,621 | 75.7 | 165 | 12,480 | | | | 92.4 | 250 | 23,101 |
| Cotton | 6.3 | 749 | 4,719 | 11.9 | 212 | 2,523 | | | | 18.2 | 398 | 7,242 |
| Total | 140.4 | 495 | 69,574 | 711.3 | 275 | 195,285 | 42.2 | 841 | 35,500 | 893.9 | 336 | 300,360 |

[1] Based on U.S. Dept. Agr. Staff paper, Projected Agricultural Transportation Requirements, Oct. 2, 1970; and U.S. Dept. Agr. Staff paper, projected Agricultural Transportation Requirements—Modal Distribution, Oct. 30, 1970; and estimates on mileage by commodity by mode of travel by Ed Heitz, Traffic Manager, Agr. Mkt. Serv., U.S. Dept. Agr., June 8, 1973. Excludes Alaska and Hawaii.

[2] Includes farmer owned trucking and commercial trucking.

[3] From DOT Statement TD-1, Year 1969, Carloan Waybill Statistics, 1969, Office of Systems Analysis and Information, U.S. Dept. Transp., Washington, D.C., 20590.

[4] Includes mileage for trucks returning empty.

TABLE 64.—AGRICULTURAL PRODUCT TRANSPORTATION: FUEL NEEDS, MILEAGE AND TON SHIPPED, 1965, 1970 1975, AND 1980[1]

| Mode of transportation | Tons[2] (millions) | Miles[3] | Ton miles (millions) | Ton miles—per gallon[4] | Gallons (millions) Diesel | Gasoline |
|---|---|---|---|---|---|---|
| 1965 | | | | | | |
| Rail | 110.0 | 485 | 53,322 | 250 | 213.3 | |
| All trucks | 500.9 | 301 | 150,873 | 48 | 2,821.1 | 327.3 |
| Commercial | 247.7 | 569 | 141,054 | 50 | 2,821.1 | |
| Farm | 253.2 | 39 | 9,819 | [5] 30 | | |
| Water | 31.3 | 882 | 27,610 | 220 | 125.5 | |
| All modes | 642.2 | 361 | 231,805 | 66 | 3,159.9 | 327.3 |
| 1970 | | | | | | |
| Rail | 118.1 | 497 | 58,725 | 250 | 234.9 | |
| All trucks | 559.4 | 291 | 162,710 | 48 | 3,028.5 | 376.1 |
| Commercial | 266.8 | 568 | 151,426 | 50 | 3,028.5 | |
| Farm | 292.6 | 39 | 11,284 | [5] 30 | | 376.1 |
| Water | 34.6 | 870 | 30,090 | 220 | 136.8 | |
| All modes | 712.1 | 353 | 251,525 | 67 | 3,400.2 | 376.1 |
| 1975 | | | | | | |
| Rail | 130.6 | 495 | 64,675 | 250 | 258.7 | |
| All trucks | 640.2 | 284 | 181,890 | 48 | 3,387.7 | 416.8 |
| Commercial | 305.6 | 554 | 169,386 | 50 | 3,387.7 | |
| Farm | 334.6 | 37 | 12,504 | [5] 30 | | 416.8 |
| Water | 38.7 | 858 | 33,200 | 220 | 150.9 | |
| All modes | 809.5 | 346 | 279,765 | 66 | 3,797.3 | 416.8 |
| 1980 | | | | | | |
| Rail | 140.4 | 495 | 69,574 | 250 | 278.2 | |
| All trucks | 711.3 | 275 | 195,286 | 48 | 3,619.3 | 429.7 |
| Commercial | 327.4 | 554 | 180,964 | 50 | 3,619.3 | |
| Farm | 383.9 | 37 | 14,322 | [5] 30 | | 429.7 |
| Water | 42.2 | 841 | 35,500 | 220 | 161.4 | |
| All modes | 893.9 | 336 | 300,360 | 67 | 4,058.9 | 429.7 |

[1] Excludes Alaska and Hawaii.
[2] From U.S. Department of Agriculture staff paper, October 2, 1970.
[3] Estimates largely from Ed Heitz, Traffic Manager, Agr. Mktg. Serv., U.S. Department of Agriculture.
[4] Lincoln, G.A., Energy Conservation, Science, Vol. 180, Apr. 13, 1973.
[5] Estimates from Econ. Res. Serv., U.S. Department of Agriculture.

These increases are based on the assumption that trucks will continue to dominate the agricultural product transportation system. Reorganization of railroads, reduced speed limits, higher fuel costs, and other governmental actions in the next few years could change these projections. However, because of the complexity of the transportation system and the time required to increase mode capacities, trends are unlikely to change significantly between 1974 and 1980 from those in the past.

*Energy intensiveness an important factor*

From a long range viewpoint, the greater fuel efficiencies of water and rail over truck transportation cannot be ignored. Depending on how much fuel costs rise relative to other input costs in the food and fiber industry, fuel efficiencies of alternative transportation modes will become increasingly important.

Energy intensiveness or Btu per ton mile is greatest for airplanes and lowest for pipelines. However, of major importance to agriculture is the difference in energy intensiveness of truck, rail, and water. Energy intensiveness for water and rail in 1970 was about 700 Btu per ton mile or about one-fourth of the Btu used per ton mile in trucking (figure 9).

The difference in energy intensiveness between rail and truck transport started about 1951. It has widened sharply and consistently from that year to 1970. Energy intensiveness in trucking rose slowly between 1950 and 1970. Energy intensiveness of railroads declined

to less than one-fourth of the 1950 level in 1950–70 because of the shift from coal-burning steam locomotives to diesel-engine locomotives.

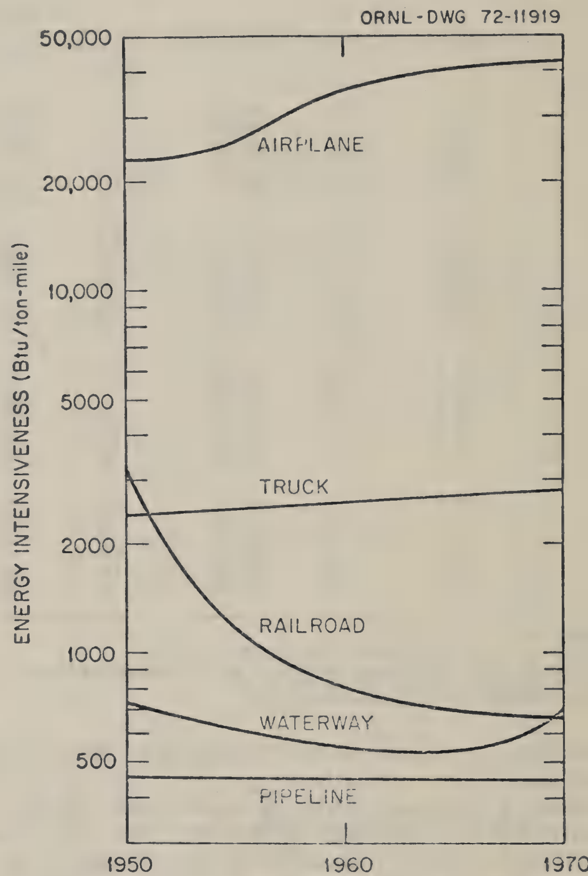


FIGURE 9.—Historical variation in energy intensiveness for intercity freight modes, plotted semilogarithmically.

## FOOD RETAILING

In the past few decades, vast and important changes have occurred in food retailing as they have in other parts of the marketing and distribution system. Though grocery retailing remains an industry of large numbers, store numbers have been declining since 1940—from 353,000 in that year to 200,000 in 1973. Further, grocery sales have become increasingly concentrated in large stores. Supermarkets, comprising 20 percent of all grocery stores in 1973, accounted for 79 percent of all grocery store sales in that year [40, 44].

The supermarket developed from changes occurring both for consumers and the retail industry. Small family grocery and general merchandise stores were common and convenient in times of relatively poor transportation and few home-storage facilities. However, as private automobiles became more available for shopping and home facilities more prevalent for storing food, consumers began to travel further and purchase groceries in larger amounts. Further, the increased use of self service in retail grocery operations allowed significant savings in labor costs per dollar of sales. With larger sales volumes, stores could departmentalize and specialize their employees and managers.

The evolution of the supermarket as a place in which consumers purchase many of their needs, both food and non-food, has significantly affected the use of energy in the marketing system. Modern stores rely on the extensive use of lighting fixtures designed to emphasize special store displays, enhance meat and produce by increasing the brilliance of packaging, and reduce eye fatigue of customers and employees. Large, convenient open cooler and freezer display cases have replaced the small enclosed freezers and coolers typical in the past. Central air-conditioning and heating are almost universal in large stores, often supplemented by additional heating needed in areas where open-front chilled or frozen food cases are located. A wall of single-thickness glass has replaced small display windows, further increasing heating and air-conditioning requirements.

Some indication of the extent of energy use in supermarkets, for the entire store and its individual departments, may be found in table 65. For the entire supermarket, energy costs average 0.36 percent of sales; however, significant differences exist among major departments. Produce displays are usually quite large, require refrigeration and ice and, consequently, significant energy input. The energy impact of frozen foods is more dramatic; display cases containing these products need compressors for freezing.[10] Meat and dairy products are usually displayed in open chilling cases, which increase the amount of energy used. Dry, less perishable groceries require less energy input than items in the other departments. Stores pay a relative high cost to package meat; individual cuts are often set in paperboard or plastic trays and wrapped with clear poly vinyl chloride material made from petrochemicals.

*Eating away from home*

As another facet of the food marketing system's energy requirement, demand for meals away from home has risen in the past two decades. Fueled by rising personal disposable income (almost a 60 percent increase) and greater numbers of working wives, restaurants, fast food outlets, and other prepared food and drink businesses have increased sales over 30 percent since the early 1950's.[11]

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[10] An 8 foot, 3-shelf uncovered freezer display case commonly uses a 5 horsepower compressor. A similar covered unit requires a 1.5 horsepower unit.

[11] Changes in disposable income and sales are based on constant 1967 dollars.

TABLE 65.—ESTIMATED IN-STORE GROSS COSTS, MARGINS, AND PROFITS OF SUPERMARKETS, BY MAJOR DEPARTMENTS, 1972 [1]

[Percent of sales]

| Item | Meat | Produce | Dry grocery | Dairy [2] | Frozen foods | Total store |
|---|---|---|---|---|---|---|
| Merchandise | 78.80 | 69.00 | 86.73 | 80.79 | 75.60 | 82.53 |
| Labor | 11.51 | 15.58 | 6.92 | 8.78 | 10.91 | 8.94 |
| Packaging | 1.72 | .31 | .31 | .19 | .80 | .63 |
| Repairs | .34 | .96 | .38 | .30 | .92 | .43 |
| Utilities | .74 | 2.70 | .27 | .75 | 3.10 | .73 |
| Energy [3] | (.37) | (1.35) | (.14) | (.38) | (1.55) | (.36) |
| Depreciation | .49 | 1.41 | .56 | | 1.35 | .63 |
| Business taxes | .76 | 1.46 | .50 | | 1.22 | .64 |
| Rent | 1.01 | 2.88 | 1.15 | | 2.77 | 1.29 |
| Interest | .13 | .17 | .08 | | .05 | .12 |
| Advertising [4] | 1.80 | 1.80 | 1.80 | | 1.80 | 1.80 |
| Other | 1.68 | 2.38 | .68 | | 1.12 | 1.32 |
| Profit before taxes | 1.02 | 1.35 | .62 | | .36 | .94 |
| Total | 100.00 | 100.00 | 100.00 | | 100.00 | 100.00 |

[1] In-store margins exclude warehousing and delivery costs and headquarters expense.
[2] Includes ice cream and other refrigerated items such as bakery products, fruit juices, and dips.
[3] Assumes energy is one-half of utilities.
[4] Includes 0.05 cent for labor.

Source: U.S. Department of Agriculture, Econ. Res. Serv., ERS-14, Developments in Marketing Spreads for Agricultural Products in 1973. 1974.

Though total expenditures for food away from home have doubled since 1960, per capita outlays have gained only 10 percent since that time, and not at all since 1966.

Eating away from home likely has both positive and negative effects on energy consumption. Cooking quantities of food larger than those required by individual families probably reduces the amount of energy needed to prepare each unit of food away from home. Further, the energy involved in manufacturing packaging materials and in packaging the individual units of products is reduced. However, substantial volumes of fuel—primarily gasoline—are used to transport customers to these eating establishments. Amounts of fuel are almost certainly increasing since business in these establishments is going up. The net effect on energy consumption of increased meals away from home is not known.

# THE INPUT INDUSTRY

A commercial farm is as much an assembly plant as a Detroit automobile plant. Farmers purchase most of their production inputs from manufacturers. They assemble them at the farm using their managerial skills to apply the right combination of seed, fertilizer, pesticides, machinery, fuel and other inputs to produce the largest possible amount of high quality farm goods that will return them a satisfactory income. The inputs purchased by farmers require energy in their manufacture and transport to the farm. Energy data for feedstock and for heat and power in production of some inputs are available and reported here. For other inputs, energy data are either confounded by multiproduct manufacture in which only a portion is agriculturally related or they are not available.

## FEED

Industries engaged in providing farmers with feed and feed ingredients include: prepared feed and feed ingredients (SIC 2042), animal and marine fats and oils (SIC 2094), cottonseed oil mills (SIC 2091), and soybean oil mills (SIC 2092). However, because of data limitations only the first two will be discussed.

The primary fuel used in both industries was natural gas which accounted for 62 percent of the energy for heat and power in 1971 (table 66). Fuel oil and electricity were also important. The Btu per dollar of value added was lower for both industries in 1971 than in 1962 (table 67).

*Prepared feeds and feed ingredients (SIC 2048)*

Establishments in this industry manufacture feeds, feed ingredients, and adjuncts for animals and fowls. Products processed include alfalfa meal, feed supplements, feed concentrates, and feed premixes.

TABLE 66.—HEAT AND POWER FOR INDUSTRIES PRODUCING ANIMAL FEEDS (SIC 2042 AND 2094), 1962, 1967, AND 1971

| Industry and Year | Fuel oil (1,000 barrels) Distillate | Fuel oil (1,000 barrels) Residual | 1,000 short tons Coal | 1,000 short tons Coke | Natural gas (billion cubic feet) | Other (million dollars) | Purchased electricity (billion kilowatt-hours) | Total |
|---|---|---|---|---|---|---|---|---|
| Prepared Feed and Feed Ingredients: | | | | | | | | |
| 1962 | (955) | | 69 | 0 | 14.7 | 2.8 | 1.3 | NA |
| 1967 | 332 | 278 | 112 | 0 | 22.6 | 6.2 | 1.6 | NA |
| 1971 | 524 | 168 | 58 | (S) | 27.3 | 7.0 | (E) 2.2 | NA |
| Animal and Marine Fats and Oils: | | | | | | | | |
| 1962 | (772) | | 257 | 7 | 10.5 | 2.7 | .2 | NA |
| 1967 | 352 | 541 | 138 | 0 | 11.3 | 3.3 | .4 | NA |
| 1971 | 684 | 614 | 26 | 0 | 20.2 | 3.6 | (E) .8 | NA |

See footnotes at end of table, p. 78.

TABLE 66.—HEAT AND POWER FOR INDUSTRIES PRODUCING ANIMAL FEEDS (SIC 2042 AND 2094), 1962, 1967, AND 1971—Continued

| Industry and year | Fuel oil (1,000 barrels) Distillate | Fuel oil (1,000 barrels) Residua | 1,000 short tons Coal | 1,000 short tons Coke | Natural gas (billion cubic feet) | Other (million dollars) | Purchased electricity (billion kilowatt-hours) | Total |
|---|---|---|---|---|---|---|---|---|
| | Billion Btu | | | | | | | |
| Feed and Feed Ingredients: | | | | | | | | |
| 1962 | (5,783) | | 1,808 | 0 | 15,214 | 1,624 | 4,436 | 28,865 |
| 1967 | 1,934 | 1,748 | 2,934 | 0 | 23,391 | 3,596 | 5,459 | 39,062 |
| 1971 | 3,052 | 1,056 | 1,520 | (S) | 28,256 | 4,060 | (E) 7,506 | 45,450 |
| Animal and Marine Fats and Oils: | | | | | | | | |
| 1962 | (4,675) | | 6,733 | 42 | 10,868 | 1,566 | 682 | 24,566 |
| 1967 | 2,050 | 3,401 | 3,615 | 0 | 11,696 | 1,914 | 1,365 | 24,041 |
| 1971 | 3,984 | 3,860 | 681 | 0 | 20,907 | 2,088 | (E) 2,730 | 34,250 |
| Total: | | | | | | | | |
| 1962 | (10,458) | | 8,541 | 42 | 26,082 | 3,190 | 5,118 | 53,431 |
| 1967 | 3,984 | 5,149 | 6,549 | 0 | 35,087 | 5,510 | 6,824 | 63,103 |
| 1971 | 7,036 | 4,916 | 2,201 | (S) | 49,163 | 6,148 | 10,236 | 79,700 |

(S) Withheld from publication.
(E) Estimated.
NA Not applicable.

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of the Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., Apirl 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., July 1973.

TABLE 67.—HEAT AND POWER AND VALUE ADDED BY MANUFACTURE FOR INDUSTRIES PRODUCING ANIMAL FEEDS (SIC 2042 AND 2094), 1962, 1967, AND 1971

| Year | Btu for heat and power (billions) | Value added by manufacture (millions) | Btu per dollar value added |
|---|---|---|---|
| Feed and Feed Ingredients: | | | |
| 1962 | 28,865 | $881 | 32,764 |
| 1967 | 39,062 | 1,227 | 31,835 |
| 1971 | 45,450 | 1,542 | 29,475 |
| Animal and Marine Fats and Oils: | | | |
| 1962 | 24,566 | 168 | 146,226 |
| 1967 | 24,041 | 206 | 116,704 |
| 1971 | 34,250 | 278 | 123,201 |
| Total: | | | |
| 1962 | 53,431 | 1,049 | 50,935 |
| 1967 | 63,103 | 1,433 | 44,036 |
| 1971 | 79,700 | 1,820 | 43,791 |

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of the Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of the Census, Washington, D.C. April 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., July 1973.

TABLE 68.—HEAT AND POWER FOR PRODUCING ANIMAL FEEDS, 1971 AND 1980

| Industry | SIC code | Quantity form | 1971 Quantity | | 1971 Billion Btu | 1980 Quantity | | 1980 Billion Btu |
|---|---|---|---|---|---|---|---|---|
| Prepared feeds and feed ingredients: | 2042 | | | | | | | |
| Formula feeds | | Final product | 101.0 | mil. tons | 68,983 | 115.5 | mil. tons | 78,886 |
| Dehydrated alfalfa | | do | 1,609 | thou. tons | 22,832 | 1,476 | thou. tons | 29,944 |
| Sun-cured alfalfa | | do | 417 | do | 1,011 | 637 | do | 1,544 |
| Dehydrated citrus pulp | | do | 340 | do | 4,733 | 445 | do | 6,195 |
| Total | | | | | 97,559 | | | 107,569 |
| Animal and marine fats and oils:[1] | 2094 | | | | | | | |
| Animal reduction | | Raw product | 10,874 | mil. lbs | 26,212 | 13,426 | mil. lbs | 32,424 |
| Fish reduction | | do | 3,034 | do | 7,737 | 4,028 | do | 10,271 |
| Total | | | | | 33,949 | | | 42,695 |
| Total | | | | | 131,508 | | | 150,264 |

[1] Includes fuel needs for trucks and boats used to assemble the raw materials.

The energy requirements per ton of final product for this industry's processing activities are as follows: formula feeds—683,000 Btu; dehydrated alfalfa—14.2 million Btu; dehydrated citrus pulp—13.9 million Btu; and sun-cured alfalfa—2.4 million Btu [20]. Natural gas, the most important fuel source in 1971, accounted for 53 percent of the heat and power energy requirements. Electricity was second at 36 percent (table 49).

The formula feeds industry is composed of primary and secondary manufacturing. Primary feed manufacturing involves the processing and mixing of individual feed ingredients such as feed grains, mill byproducts, oilseed meals, and animal proteins. Secondary feed manufacturing concerns the processing and mixing of one or more ingredients with formula feed supplements [34]. An estimated 101 million tons of formula feeds, primary and secondary, were produced in 1971; this figure is 115.5 million tons in 1980. Energy for heat and power is estimated to increase by 14 percent to 78.9 trillion Btu in 1980 (table 68).

Production of dehydrated alfalfa is expected to continue its decline—from 1.6 million tons in 1971 to 1.5 million tons in 1980. The high price of land plus the good prices for corn and soybeans have caused a shift from alfalfa to these more profitable crops. The high energy requirement of 14.2 million Btu per ton of final product may accelerate this trend. On the other hand, processing of sun-cured alfalfa will go from 417,000 tons in 1971 to 637,000 tons in 1980. Its energy needs are only 17 percent those of dehydrated alfalfa—2.4 million Btu, compared with 14.2 million. The equipment for processing sun-cured alfalfa is the same as for green-chopped alfalfa. Thus, if energy supplies for dehydrating alfalfa are curtailed, production would not necessarily shift geographically. However, growing alfalfa for the sun-cured industry would become more risky as the farmer must leave the hay in the field to dry. More acres of alfalfa would be needed to produce a given industry output than if the alfalfa were green-chopped and processed. Production of dehydrated citrus pulp is expected to increase from 340,000 tons in 1971 to 445,000 tons in 1980; energy use for heat and power will be up 31 percent.

*Animal and marine fats and oils (SIC 2094)*

Establishments in this industry manufacture animal oils, including fish oil, and other marine animal oils as well as fish and animal meal. They also render inedible grease and tallow from animal fat, bones, and meat scraps.

The animal rendering and fish reduction process, though not complex, requires a considerable amount of energy. The energy requirements per 1,000 pounds of raw material were assumed to be 2,415 Btu for animal rendering and 2,550 Btu for fish reduction [20].

Natural gas accounted for 66 percent of the industry's energy requirements for heat and power in 1971; fuel oils (distillate and residual) and electricity each 16 percent (table 49).

The amount of raw material available to this industry for processing can vary considerably with the animal rendering being more stable than the fish reduction. The quantity of raw material available for animal rendering is influenced by the number of livestock slaughtered and death losses in the livestock industry. The fish reduction activity is dependent on fishing conditions. These vary considerably from year to year. Raw material processed by animal rendering plants is projected

to increase 23 percent—to 13.4 million pounds in 1980. The quantity of fish processed will rise a third—to 4 million pounds in 1980. Energy requirements for heat, power, and the assembly of raw materials will gain 26 percent, from 33.9 trillion Btu in 1971 to 42.7 trillion Btu in 1980.

*Outlook for 1980*

These two groups required 132 trillion Btu for heat and power in 1971. Fuel needs in 1980 are expected to be up 14 percent to 150 trillion Btu.

## Fertilizer

Determining energy requirements for heat and power and feedstocks in the fertilizer industry is a complex task. A fertilizer material may be produced and applied directly to the soil or used as an input to produce other fertilizer. There may also be intermediate steps between the production of the initial material and the final product.

Energy requirements are reported for the major fertilizer materials—where data are available. This, of course, understates the energy requirements of the industry, but will shed some light on the change in energy use associated with a substantial part of the industry output. Also, because of time and data constraints it is assumed that the energy requirement per unit of fertilizer output will remain constant between 1972–73 and 1980.

Domestic fertilizer (primary plant nutrients) production for 1972–73 and 1980 is presented below: [25]

[In thousands of short tons]

| | Nitrogen (N) | Phosphate ($P_2O_5$) | Potash ($K_2O$) |
|---|---|---|---|
| 1972–73 | 9, 560 | 6, 387 | 2, 680 |
| 1980 | 11, 100 | 9, 000 | 3, 200 |

Primary plant nutrients will increase 25 percent between 1972/73 and 1980. Phosphate production is projected to increase 41 percent, potash, 19 percent; and nitrogen, 16 percent.

Non-feedstock requirements for fertilizer manufacture and mixing increased 2½ times between 1962 and 1971 (table 69). Data on non-feedstock use for nitrogenous fertilizers and phosphoric acid are not included. Natural gas use for non-feedstocks went up dramatically.

The Btu per dollar of value added by manufacturing has increased steadily since 1963 (table 70). Between 1962 and 1967, a shift occurred from low to higher analysis fertilizers that required more energy. Between 1967 and 1971, the increase was mostly associated with a decline in fertilizer prices. Value added by manufacturing decreased from $629 million in 1967 to $601 million in 1971 although the tons of fertilizer produced were increasing.

*Nitrogen—N*

Ammonia (82 percent nitrogen) is the basic source of nitrogen (N) for fertilizer purposes. It is used directly in crop production. It is also used to produce urea, ammonium nitrate, sodium nitrate, calcium nitrate, and ammonium sulfate. All these materials have fertilizer and nonfertilizer uses. Urea, for example, is used as an input in mixed fertilizer, fed to livestock, or used in industrial production.

Ammonium nitrate is also used to produce industrial and military explosive and munitions.

Natural gas is the primary fuel used to produce anhydrous ammonia accounting for 96 percent of the 40.9 million Btu needed to produce a ton of this product. It is used as a feedstock and for heat and power in the production activity.

Because of natural gas curtailments, anhydrous ammonia production was reduced 117,000 tons in 1970, 164,000 tons in 1971, and 188,000 tons in 1972. Based on a 16-million ton industry production capacity for 1972, natural gas curtailments reduced anhydrous ammonia production 1.2 percent of capacity. In 1972, 78 percent of anhydrous ammonia production was based on firm gas contracts and 22 percent on interruptible contracts [57].

TABLE 69 — ENERGY USED FOR HEAT AND POWER IN THE FERTILIZER INDUSTRY (SIC 2871 AND 2872), 1962, 1967 AND 1971 [1]

| Year | Fuel oil (1,000 barrels | | 1,000 short tons | | Natural gas (billion cu. ft.) | Other (millions) | Purchased electricity (billion kw. hrs.) | Total |
|---|---|---|---|---|---|---|---|---|
| | Distillate | Residual | Coal | Coke | | | | |
| 1962 | (1,116) | | (S) | (S) | 13.2 | $2.2 | 1.1 | NA |
| 1967 | 282 | 308 | (S) | (S) | 28.8 | 4.4 | 2.3 | NA |
| 1971 | 336 | 127 | 37.6 | (S) | 49.8 | 2.3 | (E) 2.7 | NA |
| | Billion Btu | | | | | | | |
| 1962 | (6,759) | | (S) | (S) | 13,662 | 1,276 | 3,682 | 25,379 |
| 1967 | 1,642 | 1,936 | (S) | (S) | 29,808 | 2,552 | 7,828 | 43,766 |
| 1971 | 1,957 | 798 | 935 | (S) | 51 543 | 1,334 | 9,315 | 65 932 |

NA = Not applicable.
(S) = Withheld from publication.
(E) = Estimated.
[1] Processing of nitrogenous fertilizers and phosphoric acid is not included.

Sources: 1963 and 1967 Census of Manufacturers, U.S. Department of Commerce, Bureau of Census, Washington, D.C. Annual Survey of Manufacturers: 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C., Apr. 1973. Fuels and Electric Energy consumed, 1972 Census of Manufacturers, U.S. Department of Commerce. Bureau of Census, Washington, D.C., July 1973.

TABLE 70.—ENERGY USED FOR HEAT AND POWER AND VALUED ADDED BY MANUFACTURE IN THE FERTILIZER INDUSTRY (SIC 2871 AND 2872), 1962, 1967, 1971 [1]

| Year | Btu for heat and power [2] (billions) | Value added by manufacture (millions) | Btu per dollar of value added |
|---|---|---|---|
| 1962 | 25,379 | $387 | 65,579 |
| 1967 | 43,766 | 629 | 69 580 |
| 1971 | 64,947 | 601 | 108,065 |

[1] Processing of nitrogenous fertilizers and phosphoric acid is not included.
[2] Does not include coal.

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C., Apr. 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C., July 1973.

Total energy requirements for anhydrous ammonia production are projected to increase from 458 trillion Btu in 1972–73 to 532 trillion Btu in 1980—16 percent (table 71).

Currently about 3.5 million tons of urea are produced for all purposes. About 1.0 million tons are directly applied as fertilizer, 1.0 million tons go for livestock feed, the remainder is used for mixed

fertilizer (liquid and dry) and by industry. By 1980 the production of urea may reach 5.5 million tons.

Anhydrous ammonia is the source material from which urea is made. Nonfeedstock energy requirements per ton are 1.0 million Btu for urea in a solid form and 3.838 million Btu for urea in a solution. Heat and power energy requirements in urea production for all purposes will gain 54 percent between 1972–73 and 1980. Of the estimated 10.6 trillion Btu needed in 1980, production of solid-form urea will account for 35 percent, solutions for 65 percent.

Though ammonium nitrate, like urea, is produced as a solid and a solution, information is given only on solid ammonium nitrate production. Energy needs are projected to go from 13.9 trillion Btu in 1972–73 to 15.9 trillion Btu in 1980—up 14 percent.

*Phosphate—$P_2O_5$*

Production of $P_2O_5$ was 6.4 million tons in 1972–73 and is projected to increase to 9.0 tons by 1980. The amounts of the major phosphatic fertilizers produced in 1972–73 plus projections to 1980 are shown in table 71. These three materials account for 78 percent of the $P_2O_5$ used in fertilizer.

Ammonium phosphate, the most important material in tonnage, is also the highest in energy requirements per ton. Energy for heat and power will increase 51 percent between 1972–73 and 1980. On the other hand, energy requirements for normal and enriched superphosphate will decline one-third. Production will continue to shift from normal superphosphate to concentrated superphosphate and ammonium phosphate because more pounds of plant nutrients are contained in a ton of fertilizer. These higher analyses fertilizers substantially reduce the transportation and handling cost per pound of plant nutrient.

TABLE 71.—NONFEEDSTOCK ENERGY REQUIREMENTS TO PRODUCE SELECTED FERTILIZER MATERIALS, 1972–73 AND 1980[1]

| Ingredient | 1972/73 Btu per ton (thousands) | 1972/73 Tons of final product (millions) | 1972/73 Total Btu (millions) | 1980[2] Tons of final product (millions) | 1980[2] Total Btu (billions) |
|---|---|---|---|---|---|
| Nitrogen: | | | | | |
| Anhydrous ammonia | | 11.2 | | 13.0 | |
| Nonfeedstock | 17,897 | | 200,446 | | 232,661 |
| Feedstock | 22,997 | | 257,566 | | 298,961 |
| Total | 40,894 | | 458,012 | | 531,622 |
| Urea: | | | | | |
| Solid | 1,000 | 2.3 | 2,300 | 3.7 | 3,700 |
| Solution | 3,838 | 1.2 | 4,606 | 1.8 | 6,908 |
| Total | | 3.5 | 6,906 | 5.5 | 10,608 |
| Ammonium nitrate: Solid | 3,382 | 4.1 | 13,866 | 4.7 | 15,895 |
| Total for nitrogen | | | 478,784 | | 558,125 |
| Phosphate: | | | | | |
| Normal and enriched superphosphate | 158 | 3.1 | 490 | 1.0 | 158 |
| Concentrated superphosphate | 1,211 | 3.6 | 4,360 | 5.0 | 6,055 |
| Ammonia phosphate | 1,512 | 5.9 | 8,921 | 8.9 | 13.457 |
| Total for phosphate | | | 13,771 | | 19,670 |

See footnotes at end of table, p. 83.

TABLE 71.—NONFEEDSTOCK ENERGY REQUIREMENTS TO PRODUCE SELECTED FERTILIZER MATERIALS, 1972–73 AND 1980[1]—Continued

| Ingredient | 1972/73 Btu per ton (thousands) | 1972/73 Tons of final product (millions) | 1972/73 Total Btu (millions) | 1980[2] Tons of final product (millions) | 1980[2] Total Btu (billions) |
|---|---|---|---|---|---|
| Potash: | | | | | |
| Potassium chloride | 2,396 | 3.7 | 8,865 | 4.5 | 10,782 |
| Potassium sulfate | 1,417 | 1.5 | 2,126 | 1.8 | 2,551 |
| Total for potash | | | 10,991 | | 13,333 |
| Total for nitrogen, phosphate, and potash | | | 503,546 | | 591,128 |

[1] Includes feedstock requirements for anhydrous ammonia.
[2] Estimates developed by Econ. Res. Serv., U.S. Department of Agriculture.

Sources: The Fertilizer Supply: 1973/74, U.S. Department of Agriculture, Agr. Stab. Cons. Serv., Washington, D.C., July 1974. U.S. and World Fertilizer Outlook. Subcommittee on Agricultural Credit and Rural Electrification, Committee on Agriculture and Forestry, U.S. Senate, March 1974. White, William C., Fertilizer—Food—Energy Relationships, Proceedings, Division of Fertilizer and Soil Chemistry, American Chemical Society, Chicago, Ill., August 1973.

*Potash—$K_2O$*

Domestic production of $K_2O$ was 2.7 million tons in 1972–73 and may reach 3.2 million tons in 1980. Potassium chloride accounted for 85 percent of the total domestic $K_2O$ in 1972–73 and potassium sulfate 11 percent. Well over half of the potash used in agricultural production is imported. Energy requirements for heat and power in potash production are projected to increase 21 percent between 1972–73 and 1980.

*Outlook for 1980*

Total energy requirements—feedstock and nonfeedstock—for the selected fertilizer materials are projected to increase from 504 trillion Btu in 1972–73 to 591 trillion Btu in 1980—17 percent. Anhydrous ammonia production accounts for about 90 percent of the total energy requirement—50 percent in feedstock and 40 percent in nonfeedstock.

## Farm Machinery

The value added by manufacture in the farm machinery industry (SIC 3522) increased about 70 percent between 1963 and 1967. Since then it has dropped slightly, and in 1971, was $2 billion. Energy used for heat and power increased only 12 percent since 1962, and Btu per dollar of value added declined by about one-third (table 72).

Of all fuels purchased for heat and power by farm machinery manufacturers in 1971, the most significant were natural gas, coal and purchased electrical energy. Use of coal dropped 56 percent from 1967, while use of electrical energy and natural gas rose 30 percent and 25 percent, respectively. Btu of total fuels and electric energy purchased for heat and power declined 6 percent between 1967 and 1971 (table 73).

*Energy related shortages*

In 1973, and thus far in 1974, farmers have been unable to obtain all farm machinery and equipment they have ordered. The inability of manufacturers to satisfy this demand is only partly related to the energy shortage.

TABLE 72.—ENERGY USED FOR HEAT AND POWER, AND VALUE ADDED BY MANUFACTURE, FARM MACHINERY INDUSTRY (SIC 3522), 1962, 1967, AND 1971

| Year | Btu for heat and power (billions) | Value added by manufacture (millions) | Btu per dollar value added |
|---|---|---|---|
| 1962 | 27, 963 | $1, 206 | 23, 187 |
| 1967 | 33, 310 | 2, 042 | 16, 312 |
| 1971 | 31, 384 | 1, 993 | 15, 747 |

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C., Apr. 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C., July 1973.

TABLE 73.—ENERGY USED FOR HEAT AND POWER, FARM MACHINERY INDUSTRY (SIC) 3522); 1962, 1967, AND 1971

| Year | Fuel oil (1,000 barrels) | | Coal (1,000 short tons) | Coke (1,000 short tons) | Natural gas (billion cubic feet) | Other (millions) | Purchased electricity (billion kilowatt-hours) | Total |
|---|---|---|---|---|---|---|---|---|
| | Distillate | Residual | | | | | | |
| 1962 | (316) | | 437 | 92 | 10.9 | $1.6 | 0.7 | NA |
| 1967 | 173 | 112 | 458 | 94 | 13.9 | 3.1 | 1.0 | NA |
| 1971 | 195 | 105 | 204 | (S) | 17.4 | 3.1 | 1.3 | NA |
| | Billion Btu | | | | | | | |
| 1962 | (1, 914) | | 11, 449 | 2 | 11, 282 | 928 | 2, 388 | 27, 963 |
| 1967 | 1, 008 | 704 | 12, 000 | 2 | 14, 386 | 1, 798 | 3, 412 | 33, 310 |
| 1971 | 1, 136 | 660 | 5, 345 | (S) | 18, 009 | 1, 798 | 4, 436 | 31, 384 |

NA—not applicable.
(S) Withheld from publication.

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C., April 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of Census Washington, D.C., July 1973.

The record net farm income in 1972 and 1973 brought an unexpected demand for farm machinery. Instead of 130,000–135,000 tractors per year, farmers bought 157,000 in 1972 and 197,000 in 1973. This demand has stripped the inventory of new tractors. Farmers have been ordering machinery with delivery dates of from 3 months to a year away.

On existing production lines manufacturers have been impeded in boosting output by shortages of tractor tires, castings, machine tools, and some plastic parts. The tire and plastic parts shortages are energy related. Petroleum feedstocks for these items have not been available in the volume needed. Some manufacturers are expanding production lines for longer run increases in output, but immediate demand remains unmet.

*Outlook for 1980*

By 1980, demand for farm machinery is expected to reach levels approximately the same as in 1969–71. Wheel tractor sales will be 130,000 annually, and combine sales, 30,000 per year. Energy requirements are not expected to be much different from 1971 inputs of 31.4 trillion Btu.

## PESTICIDES

The United States is an important pesticide producing and exporting nation. In 1973, its pesticide industry produced 1.2 billion pounds of active pesticide materials valued at $1.3 billion (table 74) of which 27 percent was exported (table 75). Of the domestic portion, farmers used three-fifths of the products; government, industry, and homeowners used the remainder. Total value of pesticide exports was $365.5 million in 1973, 60 percent above 1972. Insecticides were 51 percent of the total value of pesticide exports in 1973; herbicides 29 percent; fungicides 13 percent; and all other pesticides, 7 percent. While an important share of exports goes to developed nations, 40 percent went to Asia, South America and Africa in 1971.

TABLE 74.—AMOUNT AND SALES VALUE OF SYNTHETIC ORGANIC PESTICIDES. 1969–73[1]

[In millions]

| Calendar year | Fungicides | | Herbicides | | Insecticides | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Pounds | Dollars | Pounds | Dollars | Pounds | Dollars | Pounds | Dollars |
| 1969 | 124.4 | 61.1 | 311.2 | 495.7 | 493.1 | 294.3 | 928.7 | 851.1 |
| 1970 | 128.9 | 65.3 | 308.1 | 498.0 | 443.9 | 307.2 | 880.9 | 870.3 |
| 1971 | 132.2 | 73.6 | 316.7 | 562.5 | 497.3 | 343.0 | 946.2 | 979.1 |
| 1972 | 128.5 | 82.2 | 353.6 | 628.0 | 539.5 | 380.6 | 1,021.6 | 1,090.8 |
| 1973 | 146.4 | 108.1 | 446.8 | 764.4 | 605.3 | 471.1 | 1,198.5 | 1,343.6 |

[1] Pounds of active ingredient.

Source: Agr. Stab. and Conserv. Serv., U.S. Department of Agriculture, "The Pesticide Review 1972," based on Tariff Commission, Chemical Division reports.

TABLE 75.—VALUE OF PESTICIDE EXPORTS BY CONTINENT OF DESTINATION, 1970 AND 1971

[In millions of dollars]

| Nation or area | Exports 1970 | Exports 1971 |
|---|---|---|
| Europe | 83.9 | 97.4 |
| North America | 39.3 | 49.7 |
| Asia | 42.5 | 46.3 |
| South America | 30.6 | 30.6 |
| Africa | 17.6 | 20.0 |
| Australia and Oceania | 6.4 | 7.6 |
| Total | 220.3 | 251.6 |

Source: Agr. Stab. and Conserv. Serv., U.S. Department of Agriculture, "The Pesticide Review," based on Bureau of Census Report FT 246, TSUSA schedule 405–1500 and FT 410.

TABLE 76.—QUANTITIES OF SELECTED PESTICIDES USED BY FARMERS, UNITED STATES, 1966 AND 1971[1]

[Thousand pounds]

| Type of pesticide product [2] | Pounds of active ingredients | | | | |
|---|---|---|---|---|---|
| | | 1971 | | | |
| | 1966 total | Total | Crops [3] | Livestock [4] | Other [5] |
| Fungicides [6] | 33,204 | 41,727 | 39,555 | 514 | 1,658 |
| Herbicides [7] | 115,330 | 227,906 | 225,660 | | 2,246 |
| Insecticides [7] | 148,924 | 169,770 | 154,256 | 14,784 | 730 |
| Miscellaneous pesticides [8] | 55,783 | 54,706 | 46,272 | 569 | 7,865 |
| Total pesticides (not including sulfur of petroleum) | 353,241 | 494,109 | 465,743 | 15,867 | 12,499 |
| Sulfur | 57,101 | 112,453 | 112,093 | 358 | 2 |
| Petroleum [9] | 92,160 | 221,528 | 203,474 | 13,126 | 4,928 |
| Total (including sulfur and petroleum) | 502,502 | 828,090 | 781,310 | 29,351 | 17,429 |

[1] Does not include Alaska.
[2] All technical pesticide materials classified by anticipated major use. Each ingredient, except sodium chlorate, included in only one category. Sodium chlorate is included under herbicides and defoliants and dessicants.
[3] Includes all crops, pasture, rangeland, and land in summer fallow.
[4] Includes livestock buildings.
[5] Includes pesticides for all other noncrop and nonlivestock uses.
[6] Not including sulfur.
[7] Not including petroleum.
[8] Includes all uses of rodenticides.
[9] Used primarily in insecticidal and herbicidal preparations.

Farmers used about 494 million pounds of pesticide products (not including sulfur and petroleum) to control fungi, weeds, insects, mites, nematodes, and rodents; and to aid in harvesting and regulating growth. Farm use of pesticides, other than sulfur and petroleum, increased about 40 percent between 1966 and 1971 (table 76) [2]. Using herbicides to control weeds is an alternative to mechanical cultivation and hand weeding. Farmers purchases of herbicides doubled from 1966 to 1971, an increase of 113 million pounds. In 1971, herbicides accounted for close to half the pesticide materials used on farms, compared with only a third in 1966.

Fungicide use (other than sulfur) rose 25 percent since 1966. Sulfur, though, is still the most widely used fungicide product, accounting for nearly three times as many pounds as all other fungicides combined. Petroleum products, mainly oils, are used primarily in insecticidal and herbicidal preparations. Petroleum use as a pesticide increased 2.5 times from 1966 to 1971.

*Basic Pesticide Production*

Energy—chiefly petroleum—is crucial to the pesticide industry as an input in the basic production and formulation processes.

Many, if not most, of the 300 basic pesticide chemicals are synthesized from petroleum. Pesticides are initially derived from such petroleum products as propane, butane, and naphtha. These products will normally be processed through several intermediate stages before the pesticide chemical is synthesized. If any of the necessary intermediates are absent, the final pesticide product cannot be synthesized.

Pesticide production also requires heat during synthesis, frequently steam. Thus, this industry needs petroleum both as feedstock, chemical intermediate, and for heat and power in processing.

*Pesticide Formulation*

The major formulation ingredient (by volume), the solvent, is generally a petroleum product, at least for the emulsifiable concentrates. The major share of insecticide and miticide chemicals and some fungicides and herbicides are formulated as emulsifiable concentrates. The formulation process also requires heat to combine the solvent and intermediate chemicals into stable marketable formulations.

*Energy Use*

The value added by manufacture and Btu for heat and power rose over three-fold from 1962 to 1971 while Btu per dollar of value added decreased 11 percent—to 17,190 in 1971 (table 77).

On a Btu basis, natural gas is the most important source of energy—nearly two-thirds (table 78). Coal and electricity are other major energy sources.

*Current Fuel Related Problems*

During the past season, serious shortages of some important pesticide products were reported in the United States. The situation may well deteriorate next year and in succeeding years. More serious shortages were avoided this year by drawing upon inventories that were stockpiled for the 1975 season. Thus, the problem will be greater next year unless the overall supply situation improves substantially.

During the spring planting season, shortages of cotton, soybean, and wheat herbicides were frequently reported including 2,4-D for wheat, trifluralin and fluometuron for cotton, and trifluralin for soybeans. Some specialists estimated that 2,4-D fell 40 percent short of meeting U.S. demand for wheat this spring. In Department monitoring surveys, 11 States reported shortages of some products in April, 24 States reported shortages in May, and 44 States in June. Extended wet weather in much of the Midwest aggravated the situation as growers had to replant and re-treat some fields with pesticides.

TABLE 77.—ENERGY USED FOR HEAT AND POWER AND VALUE ADDED BY MANUFACTURE IN THE PESTICIDES AND AGRICULTURAL CHEMICALS, N.E.C. (SIC 2879): 1962 AND 1967

| Year | Btu for heat and power (billions) | Value added by manufacture (millions) | Btu per value added |
|---|---|---|---|
| 1962 | 2,823 | $146 | $19,336 |
| 1971 | 8,733 | 508 | 17,190 |

Sources: 1963 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C., April 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C., July 1973.

TABLE 78.—ENERGY USED FOR HEAT AND POWER, PESTICIDES AND AGRICULTURAL CHEMICALS, N.E.C. (SIC 2879): 1962 AND 1971

| Year | Fuel oil (1,000 barrels) Distil-late | Residual | Coal (1,000 short tons) | Coke (1,000 short tons) | Natural (billion cubic feet) | Other (million) | Purchased electricity (million kilowatt hours) | Total |
|---|---|---|---|---|---|---|---|---|
| 1962 | (87) | | (S) | (S) | 1.7 | $.3 | 106 | NA |
| 1971 | 53 | 62 | 60.8 | (S) | 6.2 | 1.2 | (E) 270 | NA |
| | Billion Btu | | | | | | | |
| 1962 | (527) | | (S) | (S) | 1,760 | 174 | 362 | 2,823 |
| 1971 | 309 | 390 | 1,593 | (S) | 6,417 | 696 | 921 | 10,326 |

NA=Not applicable.
(E) Estimated.
(S) Withheld from publication.

Sources: 1963 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C., April 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C., July 1973.

Methyl parathion is reported to be in short supply this summer. It is used mainly for cotton bollweevil and bollworm control. Except for a few products, which were in very short supply, prices were not considered to be up more than about 15 percent over last year.

The current tight pesticide situation has resulted from the greatly increased demand and moderately larger supply of pesticides—both in the United States and worldwide. The increased acreage of corn, cotton and wheat in the Nation increased the quantity of pesticide demanded an estimated 10 percent over the 1973 level. In addition, farmers with high crop price expectations want to use pesticides to assure good crop yields. The growth in demand for pesticides in other countries is also increasing rapidly, which pressures suppliers to fulfill these demands.

The supply of pesticides is tight for several reasons. Earlier, price controls may have put pesticide manufacturers in a poor competitive position with some other industries allowing basic petrochemicals to be diverted for the manufacture of products other than pesticides. Price controls also kept domestic prices down relative to export prices, which increased the proportion of pesticides going into the export market. Some chemical feedstock manufacturers experienced process problems which delayed their output. The energy situation has tightened the availability of petrochemical feedstocks used for pesticides. Petroleum based intermediate chemicals have a wide variety of uses other than for pesticides (for example, plastics). Demand for these products by other industries is undoubtedly affecting the availability of petrochemicals for pesticide production. Plant expansion to serve the growing demand for pesticides takes time and investment, and companies will not undertake such ventures without assurance of petrochemicals.

Feedstock shortages for pesticide formulation, the process in which basic chemicals are converted in finished products, could be more serious than in basic pesticide production. Not only are large quantities of petroleum required in formulating liquid emulsifiable concentrates, but the economic margin is generally considerably slimmer than in basic pesticide production.

*Outlook for 1980*

U.S. farmers will continue to demand pesticides since they rely more on chemical control for insects, diseases, and weeds in conjunction with reduced tillage practices. Furthermore, foreign demand continues to rise at a rapid rate, particularly in developing nations where relatively small amounts of pesticides have been used in the past. Energy use in 1980 is expected to increase 5 percent over over that for 1971—up to 10.9 trillion Btu.

To meet this growing demand, producers must have assurance that petroleum supplies—including the chemical intermediates—will be available and at reasonable prices.

## Petroleum Products

Refining of petroleum products requires a considerable amount of energy for heat and power—1,512 trillion Btu in 1971 (table 79). Of this 88 percent came from natural gas. It is estimated that the food and fiber sector uses 13 percent of the petroleum products which would account for 196 trillion Btu of energy in processing. The Btu per dollar of value added decreased between 1962 and 1967. However, from 1967 to 1971 it increased due to a decline in the value added by manufacture (table 80).

*Farm supply*

Petroleum products are supplied to farmers by two primary types of distributors: agents of major oil companies and independent companies, whose bulk plant and tank truck sales account for about 70 percent of the total; and farm cooperatives, which distribute about 30 percent. In some of the central and midwestern areas of the country, cooperatives supply 45 to 50 percent of the total farm market.

These distributors own or lease local bulk plants, usually with capacities of 30,000 gallons or more for liquid fuels and 60,000 gallons or more for liquified gas. Some firms have bulk plants in towns throughout the area served; other operate out of a central bulk plant in each county. Most of the refined fuels and LP gas used in farm production and home heating are delivered by tank truck to farm storage tanks, ranging in size from two 55-gallon drums to 300 to 1,000-gallon tanks. However, in the Southeast, Appalachian, Delta States, and Southern Plains regions, more than 50 percent of the farmers purchase gasoline from service stations. Further, in some areas, LP gas is provided in "bottles."

About 2,800 farmer cooperatives deliver fuels to farms from 3,350 bulk plants, using 8,600 tank trucks. Liquid fuels are moved throughout the system primarily by highway transport, although some are moved in railroad tank cars.

In the east, many firms deliver on scheduled routes, in the midwest, they commonly relay orders by short wave radio to tank truck operators in the counties.

Distributors for major companies in many areas concentrate on supplying service stations and large commercial farmers; cooperatives serve all types and sizes of farms.

Wholesale distributors usually supply retail distributors from terminal or other storage facilities. Many wholesalers buy all their products from refining companies. Others own refineries and some buy part of their requirements from other oil companies. Some also retail petroleum products. The capacity and location of storage facilities affect the wholesalers' flexibility in purchasing fuels and in making them available when seasonal demands are high. Exchange of products among oil companies is a standard procedure; such transfers help keep storage and transportation costs to a minimum and expedite availability of supplies to participating companies.

TABLE 79.—BTU OF ENERGY USED FOR HEAT AND POWER IN THE PETROLEUM REFINING INDUSTRY (SIC 2911): 1962, 1967, AND 1971

| Year | Fuel oil (1,000 barrels) | | Coal (1,000 short tons) | Coke (1,000 short tons) | Natural gas (billion cubic feet) | Other (millions) | Purchased electricity (billion kilowatt hours) | total |
|---|---|---|---|---|---|---|---|---|
| | Distillate | Residual | | | | | | |
| Total industry: | | | | | | | | |
| 1962 | (7,334) | | 789.0 | — | 942.5 | $12.1 | 11.2 | NA |
| 1967 | 354.5 | 6,908.6 | 776.9 | — | 1,119.9 | 20.6 | 17.5 | NA |
| 1971 | 1,574.2 | 9,841.7 | 344.6 | — | 1,291.1 | 31.1 | 22.6 | NA |
| | trillion btu | | | | | | | |
| 1962 | (46.1) | | 20.7 | — | 975.5 | 7.0 | 38.2 | 1,087.5 |
| 1967 | 2.1 | 43.4 | 20.4 | — | 1,159.1 | 11.9 | 59.7 | 1,296.6 |
| 1971 | 9.2 | 61.9 | 9.0 | — | 1,336.3 | 18.0 | 77.1 | 1,511.5 |
| Food and Fiber Sector Share:[1] | | | | | | | | |
| 1962 | (6.0) | | 2.7 | — | 126.8 | .9 | 5.0 | 141.4 |
| 1967 | .3 | 5.6 | 2.6 | — | 150.7 | 1.6 | 7.8 | 168.6 |
| 1971 | 1.2 | 8.0 | 1.2 | — | 173.7 | 2.3 | 10.0 | 196.4 |

[1] Assumed to be 13 percent.
— Represents zero.
NA—Not applicable.

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of the Census, Washington, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., April 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., July 1973.

TABLE 80.—ENERGY USED FOR HEAT AND POWER AND VALUE ADDED BY MANUFACTURE IN THE PETROLEUM REFINING INDUSTRY (SIC 2911): 1962, 1967, AND 1971

| Year | Btu for heat and power (trillion) | Value added by manufacture (millions) | Btu per dollar value added |
|---|---|---|---|
| 1962 | 1,087.5 | $2,966 | 366,655 |
| 1967 | 1,296.6 | 4,745 | 273,256 |
| 1971 | 1,511.5 | 4,614 | 327,590 |

Sources: 1963 and 1967 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Wasihngton, D.C. Annual Survey of Manufactures: 1971, U.S. Department of Commerce, Bureau of Census. Washington, D.C., April 1973. Fuels and Electric Energy Consumed, 1972 Census of Manufactures, U.S. Department of Commerce, Bureau of Census, Washington, D.C., July 1973.

Refineries vary greatly in size, complexity, and location. Most of those serving the central farm belt are inland and can handle only local "sweet" (low sulphur) crude oil. Many of these facilities are owned by independent companies. The large refineries located at ports along the East, Gulf and West Coasts are owned mainly by the major oil companies and can process imported "sour" (high sulfur) crude oil.

On January 1, 1973, there were 277 refineries in the United States owned by 174 companies. Eighteen companies owned 101 plants with capacities exceeding 175,000 barrels per day (B/D), which accounted for 76.7 percent of the total refinery capacity. The other 176 plants owned by 156 firms were "small" refineries (under 175,000 B/D as defined by the Emergency Petroleum Allocation Act of November, 1973). Most were also classed as "independent" refiners (those which acquired more than 70 percent of their crude from producers *not* under their control and who distributed a substantial volume of gasoline through independent marketers). Forty-five of these plants had capacities of under 5,000 B/D and constituted less than 1 percent of U.S. capacity.

Twenty-four farmer-owned wholesale cooperatives in the country supply fuels to local cooperatives; 10 of these have ownership in 8 refineries. The capacity of these refineries amounted to only 2 percent of the U.S. total. However, they supplied about two-thirds of the fuel distributed by local cooperatives. All except the refinery at Texas City, Tex., are inland.

Major oil companies produce or control production of much of the crude oil they process. But small, independent refiners must buy most of their needs from major and other crude oil producers. Some independent producers receive financial assistance from refiners, and these independents have priority on the oil.

Farmer cooperatives, owning less than 15 percent of their crude oil refining requirements, depend heavily on purchased crude oil to operate their refineries and provide fuels for farmer-members. They exchange crude oil with other companies; cooperatives owning the 7 inland refineries have had to rely on exchanges to utilize import tickets for foreign crude oil. Their reliance on buying crude oil is indicated by the fact that cooperatives were eligible to purchase 92,337 barrels of crude per day under the Crude Oil Allocation Program for June-August 1974. This amount was about 35 percent of their refining capacity.

*Problems arise in times of shortage*

Historically, agriculture has experienced difficulty when fuel supplies become short. During World War II, cooperatives, for example, had trouble buying gasoline, kerosene, and fuel oils from their sources of supply; namely, independent and major oil companies. To help relieve the problem, the cooperatives purchased several small refineries and were operating 20 by the end of the War. Although crude oil shortages occurred briefly later on, cooperatives had no long-term difficulties in buying crude.

During the recent shortages, regional wholesale cooperatives did have trouble in buying refined fuels, propane, and crude oil. They also had to pay premium prices on substantial quantities of fuels to keep supplies moving to local cooperatives and their farmer-members.

In the mid-1950's, the United States changed from an exporter to an importer of crude oil. From then until 1972, imported crude oil cost substantially less than domestic. During this period, a governmental regulated system was established to limit imports; the right to purchase oil was apportioned to all refiners, both coastal and inland, so that all could share in the low-cost foreign crude oil.

In 1972, the price of imported crude oil rose above that for domestic crude oil. Cooperatives and other independents began to face severe supply problems. The inland facilities could no longer trade their import tickets with coastal refiners for domestic crude. Producers that formerly sold them crude oil began keeping their less expensive domestic supplies. As a result, several regional cooperatives had to cut back on their refinery production 25 percent or more. One cooperative had to close down its refinery for 6 weeks, although crude oil was moving past it to other areas.

Distribution of fuels to farmers in times of shortages is influenced by the proportion of a firm's market that is farm and nonfarm. Historically, when supplies are tight some of the major oil companies have withdrawn from less profitable rural markets in favor of more highly profitable urban markets in some States or areas. Thus problems arise as to who will serve the farmer-patrons of these companies and where the supplies will come from.

Another problem is that of making supplies available to custom combine operators (who move north from Texas to North Dakota and Montana with the grain harvest) and to migrant workers who also move with the harvest. Both groups now expect farmers to provide them with fuel.

Under the Mandatory Petroleum Allocation Program adopted in the fall of 1973 and revised early in 1974, numerous problems were encountered in making adequate fuel available for "agricultural production." Many arose because of the difficulties of developing a new program and staffing the organization with new people within a short time. There was no real precedent on which to build. Many of the regulations were revised several times and gradually, the situation improved.

Questions arose regarding the broad definition of "agricultural production" that was initially used. Should it include fuel for tobacco, flowers, and nursery products? Should it include fuel for transporting inputs to the farm and farm products from the farm? Should it include fuel for processing farm products, and if so, fuel for transporting such products to retail stores? Should it include fuel used in manufacturing feed, fertilizer, or farm machinery; or even fuel in producing raw materials for such inputs? Later the definition was defined to include certain types of production and exclude others.

Although the mandatory fuel allocation regulations provided that "agricultural production" would receive 100 percent of its current petroleum needs, they did not guarantee that the suppliers of the qualifying end-users (farmers) would be able to obtain that fuel, or that they could get all their requirements at a reasonable price. Initially, the mandatory allocation program gave priority to agricultural production, but it also stated that wholesale suppliers of heating and distillate fuel oils had to supply to the same buyers that they had in the corresponding month of 1972. If a supplier not directly supplying an end-user had an allocation fraction of less than one (his demand exceeded his supply), he had to subject fuel destined for certified "agricultural production" to his allocation fraction. As long as there were shortages, most suppliers' allocation fractions were less than one; therefore, in many cases "agricultural production" was limited to a portion rather than to 100 percent of current needs.

Another problem arose in rural areas, where independent and cooperative fuel sales were largely to agricultural patrons. Where farmers were given 100 percent of requirements, nonpriority customers sometimes received little or no supplies unless additional products could be made available. This imbalance hurt other businesses and, in turn, segments of agriculture relying on them.

Another problem was that crude oil was not allocated in the early stages of the program; hence, it did not have to be supplied to refineries on the same basis as in 1972. This made it difficult for many wholesalers to obtain their 1972 base-refined fuel volumes, and especially difficult for cooperatives and other independents whose principal business was with farmers. They could not meet 100 percent of the current agricultural requirements of their members whose requirements substantially exceeded their 1972 base volume. The problem was further compounded for those who had supplied some fuel to "spot" buyers for nonfarm use in 1972. Later changes in the regulations gave "agricultural production" 100 percent of current requirements, not subjecting it to an allocation fraction. However, difficulties were experienced in buying products and at reasonable prices. Propane was especially hard to buy.

Later changes provided that all refiners with a shortage of crude oil were entitled to buy from those with an excess, based on the national average fraction of refinery capacity/available crude oil for each quarter, as established by the Federal Energy Office. Still later changes authorized small and independent refiners who were short of the resource to buy crude oil equal to their 1972 crude runs, up to a maximum of their current refinery capacity. These changes, along with improvement in the supply situation, increased the availability of petroleum fuels to agriculture.

*Outlook for 1980*

The 1980 demand for liquid petroleum fuel for farm production will be up slightly; for family living needs down slightly; processing and transportation needs will be up in line with farm production needs. On the balance food and fiber sector liquid petroleum needs will increase 7 percent from the 1973 level. Hence, energy required in petroleum refining was estimated to increase from 196 to 211 trillion Btu between 1971 and 1980.

# FUEL COSTS AND FOOD COSTS

As fuel prices rise concern is expressed about the impact on food costs. Energy costs make up a small part of the final cost for all foods, but more is used to produce and market some foods than others. By comparing types of farms and food processing, we can gain some insight into the relative impact of rising fuel costs upon different segments of the food industry. To examine the significance of rising fuel costs upon producers and consumers, it is assumed that the same quantities of fuel would be used for production and marketing foodstuffs at each price level.

## Farmers and the Cost of Fuel

Farmers will experience higher production costs as fuel prices rise. These price increases may be great enough so that farmers will change their management policies and patterns of production.

The relative importance of energy costs can be seen by comparing selected cost and return data for Illinois farms (table 81). While there is considerable variation among individual farms in any group and Illinois farms may differ from those in other States, these records provide insight into the differential impact which might be expected on commercial farms. Fuel costs for four types of Illinois farms represent less than 5 percent of total cash sales. However, this measure understates the significance of fuel costs and their impact upon farmers' returns. Comparing fuel costs with cash farm expenses, cash balances, and earnings of labor and management reveals that rising fuel costs would have relatively more effect upon net returns than upon total costs.[12]

Return to labor and management is an indicator of well-being of farm families. While fuel costs were only 4.9 percent of cash sales for Illinois dairymen and 3.8 percent of grain farmers' cash sales, they were equivalent to almost 40 percent of labor and management earnings for the dairymen and 19 percent for the grain producers. If fuel costs are doubled, returns to labor and management for dairymen would be reduced by almost 40 percent, twice the percent reduction for grain farmers.

[12] Cash balance, the difference between cash sales and cash expenses, is used as a proxy for value added at the farm level.

TABLE 81.—RELATIONSHIP OF FUEL COSTS TO RETURNS FOR FOUR TYPES OF ILLINOIS FARMS, AVERAGE PER FARM, 1971

| Item | Unit | Type of farm | | | |
|---|---|---|---|---|---|
| | | Dairy | Beef-cattle | Hog | Grain |
| Farms | Number | 322 | 322 | 786 | 2,225 |
| Cash sales of product | Dollars | 50,277 | 143,029 | 74,642 | 68,006 |
| Cash expenses | Dollars | 37,383 | 123,206 | 58,397 | 43,184 |
| Cash balance (value added)[1] | Dollars | 12,894 | 19,823 | 16,245 | 24,822 |
| Labor and management earnings | Dollars | 6,094 | 10,031 | 8,095 | 14,071 |
| Gasoline and oil expenses | Dollars | 1,579 | 2,129 | 1,172 | 2,162 |
| Electricity as a proportion of gas and oil[2] | Percent | 39 | 20 | 57 | 17 |
| Fuel portion of hired transport as proportion of farm gas and oil.[3] | Percent | 13 | 9 | 5 | 4 |
| Total purchased fuel and energy | Dollars | 2,400 | 2,746 | 1,899 | 2,616 |
| Purchased fuel as proportion of: | | | | | |
| Cash sales | Percent | 4.8 | 1.9 | 2.5 | 3.8 |
| Cash expenditures | Percent | 6.4 | 2.2 | 3.3 | 6.1 |
| Cash balance (value added) | Percent | 18.6 | 13.9 | 11.7 | 10.5 |
| Labor and management earnings | Percent | 39.4 | 27.4 | 23.5 | 18.6 |

[1] Cash balance, the difference between cash sales and cash expenses, is considered a proxy for "value added" at the farm level.
[2] Adjustment based upon 1971 farm records for Minnesota and Iowa.
[3] Adjustment for hired transport based upon 1971 farm records for Minnesota and Iowa. Fuel portion of hired transport and freight based upon unpublished ERS summary of records covering 12.4 million truck-miles.

Such marked changes in the relative well-being of producers of different products would likely bring about changes in the production pattern and in product prices. For example, in response to fuel price increases, other things being equal, milk production is expected to decline and farm milk prices to rise relatively more than meat and grain prices.

Relating fuel costs to cash farm expenses becomes more significant to farmers as they purchase an increasing proportion of farm inputs. In 1971, Illinois dairy farmers spent about 75 cents of each sales dollar for purchased inputs. This is the average for 322 dairymen in an area where they commonly grow most of the feedstuffs for their producing herds. Cash expenses may constitute 90 percent or more of cash sales for those farmers purchasing feedstuffs on the open market.

The higher the proportion that purchased inputs are of cash sales, the greater the impact of higher input prices. A change in the price of inputs, therefore, becomes critical in its effect upon the cash balance, labor earnings and standard of living of farmers. Although the cost of fuel is a small portion of total sales, a substantial fuel price hike can be quite important. As long as the prices farmers receive for their output remain constant, the added cost of fuel may influence producers' decisions and reduce the income for family living.

Higher fuel prices would also affect the cost of production for farmers by increasing the cost of inputs other than fuel such as fertilizers and pesticides. While data on fuel costs for supplying these other farm inputs are not available, an approximation can be made by using the figure for all manufactures of 1.4 percent of value of shipments. This figure is somewhat low in that it does not include fuel for transportation of raw materials or products. Doubling the fuel cost for supplying purchased farm inputs would increase cash farm expenses but the differential impact between milk, meat, or grain producers would probably not be too significant.

TABLE 82.—ESTIMATED EFFECT ON THE RETAIL PRICE OF DAIRY, MEAT AND GRAIN MILL PRODUCTS OF DOUBLING FUEL PRICES, 1971 [1]

[In dollars]

| Contribution of— | Before fuel price increase | | After fuel price doubles (fuel increase not counted in margin) | |
|---|---|---|---|---|
| | Retail price | Fuel cost | Retail price | Fuel cost |
| Dairy products: | | | | |
| Purchased farm inputs | 0.428 | 0.006 | 0.434 | 0.012 |
| Farm production | .147 | .027 | [2] .174 | .054 |
| Processing and distribution | .175 | .006 | .181 | .012 |
| Wholesaling and retailing | .250 | .025 | .275 | .050 |
| Total | 1.00 | .064 | 1.064 | .128 |
| Meat products: | | | | |
| Purchased farm inputs | .436 | .006 | .442 | .012 |
| Farm production | .108 | .018 | [2] .126 | .036 |
| Processing and distribution | .186 | .004 | .190 | .008 |
| Wholesaling and retailing | .270 | .020 | .290 | .040 |
| Total | 1.00 | .048 | 1.048 | .096 |
| Grain mill products: | | | | |
| Purchased farm inputs | .139 | .002 | .141 | .004 |
| Farm production | .080 | .008 | [2] .088 | .016 |
| Processing and distribution | .237 | .003 | .240 | .006 |
| Wholesaling and retailing | .544 | .001 | .545 | .002 |
| Total | 1.00 | .014 | 1.014 | .028 |

[1] Assumes total pass through of fuel cost increase.
[2] In the shortrun farmers cannot pass on added fuel costs. In the longrun they will adjust supply and/or technology to where it is again profitable to produce these products.

## Food Processing Fuel Costs

Farm products must be processed and distributed to consumers by firms whose fuel costs are also increasing. Overall, the food industry tends to use less fuel per dollar of value added by manufacture than do all manufacturers. Dairy processors use more fuel per dollar of value added than any other major food industry except grain millers. However, from 1967 to 1971, the dairy products industry increased its total fuel and electrical energy purchases much less than did the other food industries. A major reason for this was due to the changing structure of the dairy processing industry.

As a result of the introduction of new energy efficient equipment, dairy processors were the only industry group in the period 1967–71 to have increased the value added per dollar of fuel purchased. In declining order of energy needs, are: cheese, condensed and evaporated milk, ice cream and frozen desserts, and fluid milk products. Because of greater energy needs, butter manufacturing would be hardest hit by increased fuel costs.

## Fuel Costs Influence Retail Prices

There is quite a variation in the relative importance of fuel costs in producing, wholesaling, and retailing different foodstuffs. Recognizing the increasing complexity of the joint cost involved, three classes of products have been differentiated by energy use at the distribution level. Here, marketing practices interact with or upon increased costs at different stages of production and marketing.

According to a recent ERS study, the marketing bill—assembly, transportation, processing, and distributing—accounted for 57 percent of the consumer's food dollar for food consumed at home, and 76

percent for food consumed away from home in 1973. Cost components of selected food items at each level in the marketing system were also estimated. For all food items studied, retail store margins ranged from 10 to 43 percent of the retail selling price, tending to cluster around 20 percent. The combined wholesale-retail margin was 25 percent of the retail price for dairy products, 27 percent for meat products, and 54 percent of the retail price for grain mill products. White bread and rice were used to represent grain mill products at the retail level.

The pricing policy and the ability of a subsector to pass increased costs on to the consumer influences the magnitude of any food price change. The effect of a fuel price increase on retail food prices depends on whether firms pass through only the absolute (direct) amount of price increase or if they base their pricing policy on a percentage markup.

The proportion that fuel costs are per dollar of retail sales varies by type of product and subsector within the food and fiber system (table 82). Fuel costs are 6.4 cents for each dollar of retail sales for dairy products and 1.4 cents for grain mill products. Farm production and wholesaling and retailing generally account for a high proportion of the fuel cost per dollar of retail sales.

With farm inputs, the effect of a fuel price increase may be gradual. Production commitments are usually made on a long term basis with the firms contracting for their fuel needs. Therefore, the impact of fuel price changes may not show up until contracts are renewed.

In the farm production sector the immediate effect of a fuel price increase would probably be minimal. Farmers cannot, in the short-run, pass on added fuel costs so they would have to accept lower returns. But in the long-run they would adjust supply and/or technology so as to again receive a profitable level of returns.

The processing of many food products is seasonal so the impact of fuel prices would be influenced by fuel prices at that point in time. For those processing throughout the year the impact would depend on their fuel contract. However, these food processing firms probably do not enter into long-term fuel contracts because many are small establishments and the amount they process varies greatly from year to year. Also, their ability to pass through costs depends on the demand for the final product.

In the distribution, wholesaling, and retailing subsectors the impact of an increase in fuel prices probably shows up relatively soon. These firms generally purchase their energy needs from local distributors and public utilities. So any change in fuel price immediately shows up in their cost structure. Historically many firms in the wholesaling and retailing industry have based their pricing policy on a percentage markup. So as costs increase they are passed on the consumer. For example, if fuel prices increase 10 cents and one assumes a retail store markup of 20 percent the effect would be an increase in the retail price of 12 cents.

The net result of an increase in fuel price on retail food prices is probably that the added costs affecting farm inputs, farm production, and processing will show up over time; while those affecting distribution, wholesaling, and retailing will show up rather quickly. In addition, because many firms use a percentage markup in determining prices the impact on retail prices will be greater than the increase in fuel price.

# POLICY IMPLICATIONS

In examining the energy needs of the food and fiber sector, a number of concerns have been surfaced that have significant policy implications. The following are considered to be important issues and principles concerning policies for energy use in the food and fiber sector.

## Availability of Fuel for the Food and Fiber Sector

Recent experience indicates that Government action is necessary in times of petroleum shortage if adequate fuel is to be made available for food and fiber production and distribution. Under a mandatory fuel allocation program clearly defined policies and procedures need to be developed that recognize the complexity and interdependence of the various subsectors of the food and fiber sector.

*Allocation*

Energy should be allocated on a top priority basis to the food and fiber system. These allocations should be consistent with national goals for food and fiber production. The allocation should cover all forms of energy including motor and non-motor fuels for generating heat and power and intermediate products vital to food and fiber production. For this top priority, all major industry participants should be required to submit and follow an energy conservation program.

*Coverage*

Activities included as vital to the operation of the food and fiber system must be clearly defined. The coverage should include the entire food and fiber chain including input supply, farm production, processing of products, movement to warehouses, and ultimate distribution to retailers. Elements that are peripheral or nonessential should be excluded from the top priority category.

*Fuel distribution*

During the recent fuel crisis, some oil firms withdrew from serving rural accounts. The impact on the food system and the remaining suppliers was serious in many localities. The petroleum companies and their distribution systems servicing food and fiber needs and the quantities and proportions of fuel that each supplier provides should be identified. Regulations should be adopted to cover the entire system to prevent further inequities.

Because of the impact of weather on volume and timing of agricultural production activities, fuels should be committed or moved to specified areas in anticipation of the peak needs of agriculture. Allocation systems should be sufficiently flexible to permit borrowing on the next month's or quarter's allocation when weather causes variation in use of fuel.



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*Petroleum industry viability*

The allocation program should protect the viability of small and independent sectors of the petroleum industry. (Congress established a statutory priority for small and independent refiners in the Emergency Petroleum Allocation Act of 1973).

Small and independent refiners should be entitled to purchase crude oil to make up for the quarterly shortages they expect, up to a maximum equal to their current refinery capacity. This would be especially helpful to cooperatives and other refiners whose principal volume goes to agricultural users. Based on the definitions of a small refiner and an independent refiner, there were 15 major oil companies having excess crude oil supplies during the June–August 1974, period who were obliged to sell crude oil at the sellers' weighted average prices to refiners-buyers having inadequate supply.

Crude oil allocation regulations now protecting cooperatives and small independent companies should be considered for extension. Otherwise, while there may be adequate or surplus supplies of specified fuels, such supplies may not always be available to small companies for re-sale to farmers at competitive prices. Strong, viable, independent and cooperative refiners and distributors need to be retained in rural areas to insure petroleum supplies to all farms.

*Petroleum pricing*

The crude oil pricing policy in effect the first half of 1974, has been inequitable to many farmers, distributors, and inland refiners who rely on high proportions of fuel produced from stripper wells. During the first half of 1974, government regulations provided for a two-tier pricing system to stimulate crude oil production. The price of domestic crude oil from old wells, exclusive of strippers, was fixed at about $5.25 a barrel. This production accounts for 70–80 percent of total domestic supply. Crude oil from newly discovered and stripper wells was exempted from price controls, and such oil sold for almost twice as much—about $10.35 a barrel. This policy discriminated against most farmer cooperative refiners and some other independent refiners because many of their inland refineries were located near fields with an unusually high percentage of stripper well production. As a result, farmers buying from these cooperatives and independents had to pay 5 to 10 cents a gallon more for their product than did farmers buying from major oil companies with more flexible access to crude oil.

*Regulation*

For an energy allocation program to work smoothly in a complex society, conflicting regulations must be kept to a minimum. Within the food and fiber system bodies have regulatory functions with respect to energy. These are the Federal Energy Administration for most petroleum fuels, the Federal Power Commission for interstate natural gas and electricity, the Atomic Energy Commission for some electricity, and the several State public utility commissions for intrastate natural gas and electricity. Some of the regulations conflict with others. Consideration should be given to developing mechanisms to provide for effective coordination among the different regulatory bodies.

## Natural Gas Problems

This study shows that natural gas provided over 30 percent of the Btu in the food and fiber sector in 1970. Many agricultural firms—because of the seasonal nature of their operations—are on interruptible natural gas contracts. Under current FPC regulations, interruptible contracts are of low priority and subject to long curtailments. The nitrogen fertilizer industry utilizes natural gas as its feedstock. Long curtailments can seriously impair the ability of the industry to satisfy the farmer's need for fertilizer. Some meat processing firms have been alerted to find alternative sources of fuel by 1978 because natural gas will not be available to them. Bleak natural gas supply prospects suggest that food and fiber industry users should be permitted to renegotiate their contracts from interruptible to firm status.[13] Otherwise, these industries will be faced with major capital expenditures for fuel conversion. Because of the short operating season of many fruit and vegetable processing plants, they may be in an economically weak position to undertake the expense of major fuel conversion; particularly after some of them have recently converted from coal to natural gas.

## Transportation

This report shows that transportation is critically important to food and fiber system. Traffic associated with food and fiber requires up to 15 percent of the fuel used in total transportation. Significant energy savings are possible in the transport of inputs and food and fiber products. However, the level of savings effected will depend upon the cooperation of regulatory authorities, transportation firms and labor unions in improving service and reducing inefficiencies.

A modal shift from truck to rail would, theoretically, reduce fuel use to about one-fourth of the current use in transporting agricultural products and inputs. However, rail and barge services are not directly available to most farmers and to many other food and fiber firms. Trucking is necessary and is the most efficient transport system for small loads and short hauls. Increased interstate shipments or longer hauls of inputs and products by rail or water could certainly lead to increased energy efficiency. But unless rail service is expanded and improved, many long haul shipments cannot be justified economically, particularly perishables or items in short supply. Our increasingly complex marketing system requires orderly and timely movements of inputs and products through the food and fiber sector. The trucking industry has more adequately adjusted to these requirements by generally providing the desired services in a timely manner. Reduced and more responsive regulations of railroads could certainly provide incentives for improved rail services to the food and fiber sector.

In addition to the intermodal shift from truck to rail and/or barge, important fuel savings in transport of food and fiber may be achieved within modes. Backhauling, improved routing and optimum load size are three of the more important areas of consideration in cutting fuel use.

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[13] The recent natural gas survey for the U.S. Federal Power Commission presents a rather dismal picture of natural gas supply to 1990. The Case II "conservative realistic" national projections expressed in terms of the annual growth rate for gas, have gas consumption growing at only 0.7 percent yearly between 1971 and 1990. In contrast, the average growth rate was 6.7 percent between 1947 and 1971.

Efforts should be made to minimize the movement of empty trailers, barges and rail cars. Competitive rate structures and deregulation of traffic could be an important step forward. Rates of the various modes should reflect the extra costs of maintaining and moving full, rather than empty trailers, barges and railcars from light demand areas back to heavy demand areas. In the regulated trucking industry which provides transportation for farm inputs and manufactured agricultural products, private trucks can haul only inputs used and products manufactured by the firm. For example, such regulation prevents some backhauls by meat trucks from New York to Colorado.

Improved traffic routing can conserve fuel. Trucking route permits are issued through the Interstate Commerce Commission. A trucking firm unable to prove public need for a particular route may not be allowed to make direct movements of freight. This could result in indirect shipment and many more truck miles traveled.

More optimum load size of barge, rail and truck movements could further reduce fuel use. Particularly in trucking, twin trailer use in hauling light and bulky freight could reduce fuel use by 20 percent. Proportionally less fuel savings would result with heavier freight. However, several States do not allow the use of twin trailers at all and only a few permit their use off the Interstate Highway System.

## Competition for Water

In the Rocky Mountains and Northern Great Plains energy development—coal and oil shale—can have high water requirements. Depending on the type of energy development—coal gasification or thermal electric generation—water needs in energy development would equal the amount to intensively irrigate 150,000 to 300,000 acres for intensive crop production annually. The value of the water for energy development may be so high that farmers cannot bid for it for agricultural uses. If so, irrigated agriculture in the area will decline, as will food production.

# LITERATURE CITED


(1) Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture, The Fertilizer Supply: 1973–74, Washington, D.C.

(2) Andrilenas, Paul A., Farmers Use of Pesticides in 1971, Ag. Econ. Rpt. 252, Econ. Res. Serv., U.S. Department of Agriculture, July 1974.

(3) Bailey, John M., Feasibility of LP Gas Cooperatives in Northern Florida, Serv. Rpt. 110, Farmer Cooperative Serv., U.S. Department of Agriculture, March 1970.

(4) Bixby, David W., Delbert L. Rucker, and Samuel L. Tisdale, Phosphatic Fertilizers: Properties and Processes, Tech. Bul. No. 8, The Sulphur Institute, Washington, D.C., October 1966.

(5) Bureau of the Census, U.S. Department of Commerce, Census of Agriculture, 1969.

(6) ———, Census of Housing: 1960, Volume 1, States and Small Areas, Part 1: United States Summary, Washington, D.C., 1963.

(7) ———, Census of Housing: 1970, Detailed Housing Characteristics, Final Report HC(1)–B1, United States Summary, Washington, D.C., 1972.

(8) ———, Census of Manufactures, 1954, Washington, D.C.

(9) ———, Census of Manufactures, 1963, Washington, D.C., 1966.

(10) ———, Census of Manufactures, 1967, Washington, D.C., 1971.

(11) ———, Current Industrial Reports, M35S and MA–35(A), 1961–74.

(12) ———, General Statistics for Industry Groups and Industries, Annual Survey of Manufacturers: 1971, M71(AS)–1, Washington, D.C., April 1973.

(13) ———, Census of Transportation, 1967.

(14) ———, Fuels and Electric Energy Consumed, 1972 Census of Manufactures, MC72(SR)–6, Washington, D.C., July 1973.

(15) Bureau of Mines, U.S. Department of Interior, Mineral Industry Surveys, (Numerous publications on fuel oil, coal, natural gas, and LP gas.) Washington, D.C., 1970–74.

(16) Carson, Karen, Special Information Report of 1972 Sales, Farm and Industrial Equipment Institute, FIEI File No. 19938–A, Chicago, Ill., April 26, 1973.

(17) Chappell, Joe S., Economic Considerations of Mechanization, paper presented to CORESTA/TCRC Joint Conference, Williamsburg, Va., October 26, 1972.

(18) Citizen Action Guide to Energy Conservation, Citizens Advisory Committee on Environmental Quality, Washington, D.C., 1973.

(19) Davulis, J. P., R. A. Andrews, and G. E. Frick, Feed Distribution and the Energy Crisis, Review manuscript, New Hampshire Agr. Expt. Sta. and Commodity Economics Division, Econ. Res. Serv., U.S. Dept. Agr.

(20) Development Planning and Research Associates, Inc., Industrial Energy Study of Selected Food Industries, a draft report to the Bureau of Mines, U.S. Department of the Interior, March 22, 1974.

(21) Economic Research Service, U.S. Department of Agriculture, Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products, Stat. Bul. No. 362.

(22) ———, Fertilizer Situation, Washington, D.C., January 1974.

(23) ———, Food Consumption, Prices, and Expenditures, Supplement for 1972 to Ag. Econ. Rpt. No. 138.

(24) ———, Interstate Custom Combining in the Great Plains, 1971.

(25) ———, U.S. and World Fertilizer Outlook AER No. 257, Washington, D.C., May 1974.

(26) Economic Research Service/Statistical Reporting Service, U.S. Department of Agriculture, Petroleum Use Survey, 1970.

(27) Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual, 1972, Washington, D.C.

(28) Farm and Industrial Equipment Institute, Unit Retail Sales of Wheel Tractors and Selected Farm Machinery, 1962–74, Chicago.

(29) Fowler, D. Lee, The Pesticide Review of 1970, Agricultural Stabilization and Conservation Service, U.S. Dept. Agr., June 1971.

(30) Gavett, Earle E., Agriculture and the Energy Crisis, paper delivered at National Conference on Agriculture and the Energy Crisis, Univ. of Nebr., Lincoln, Nebr., April 10–11, 1973.
(31) Goring, Sylvia M., Aircraft in Agriculture, FAA unnumbered report, 1972.
(32) Hirst, Eric, Efficiency of Energy Use in the United States, *Science*, pp. 1299–1304, March 30, 1973.
(33) ———, Energy Use for Food in the United States, Oak Ridge National Laboratory, National Science Foundation, ORNL–NSF–EP–57, October 1973.
(34) Hodges, Earl F., G. C. Allen, and G. A. Davis, The Formula Feed Industry, 1969—A Statistical Summary, Econ. Res. Serv., U.S. Dept. Agr., Stat. Stat. Bul. No. 485, May 1972.
(35) Joint Committee on Atomic Energy, Understanding the "National Energy Dilemma," Washington, D.C., 1973.
(36) Kohls, Richard, Marketing of Agricultural Products, 1961.
(37) Mahan, John N., The Transportation System is Changing, Part 1—Trends in Fertilizer Transportation and Storage, *Farm Chemicals*, November 1968.
(38) Manuel, Milton L. and Kent D. Shuyler, An Economic Analysis of Distributing Bulk Petroleum Products to Farms, Kansas Agr. Expt. Sta. Res. Paper 5, Manhattan, Kansas, June 1971.
(39) Mather, J. Warren and John M. Bailey, Potential for Cooperative Distribution of Petroleum Products in the South, FCS, U.S. Dept. Agr. Rpt. 21, July 1972.
(40) Moore, John and Richard Walsh, Market Structure of the Agricultural Industries, 1966.
(41) National Market Reports, Inc., National Farm Tractor and Implement Blue Book, 1974.
(42) Nebraska Center for Continuing Education, National Conference on Agriculture and the Energy Crisis, University of Nebraska, Lincoln, Nebr., April 10–11, 1973.
(43) Pimentel, E., et. al., Food Production and the Energy Crisis, *Science*, pp. 443–449, November 2, 1973.
(44) *Progressive Grocer*.
(45) Residential Energy Consumption, Multi-Family Housing Data Acquisition, Hittman Associates Inc., HUD Contract No. H–1654, Report No. HUD–HAI–3, Dept. Housing and Urban Development, Washington, D.C., 1972.
(46) Rural Electrification Administration, U.S. Department of Agriculture, 1972 Annual Statistical Report, REA Bul. 1–1, Washington, D.C., 1973.
(47) Ruttan, V. W., Food Production and the Energy Crisis: A Comment, a draft submitted for publication in *Science*.
(48) Statistical Reporting Service, U.S. Department of Agriculture, Commercial Fertilizers: Consumption in the United States Year Ended June 30, 1973, SpCr 7 (5–74), Washihgton, D.C., May 1974.
(49) ———, Statistical Bulletin No. 507, Washington, D.C., 1973.
(50) Steinhart, J. S. and C. E. Steinhart, Energy Use in the U.S. Food System, *Science*, pp. 307–316, April 19, 1974.
(51) Strickler, Paul E., H. V. Smith, and W. C. Hinson, Jr., Crop Drying in the United States, 1966, Econ. Res. Serv./Stat. Rpt. Serv., U.S. Dept. Agr., Stat. Bul. 439, June 1969.
(52) Strickler, Paul E., and B. J. Harrington, Liquid Petroleum Fuel Used by Farmers in 1959 and Related Data, Econ. Res. Serv., U.S. Dept. Agr. Stat. Bul. 344, Washington, D.C., May 1964.
(53) Train, Russell E., Statement on Conservation and Efficient Use of Energy, (Part 3), Joint Hearings, Committees on Government Operations and Science and Astronautics, House of Representatives, 93rd Congress, July 11, 1973.
(54) U.S. Department of Agriculture, Agricultural Statistics: 1973, Washington, D.C.
(55) University of Illinois, Cooperative Extension Service and Agricultural Experiment Station, Estimated Fuel Requirements for Farm Production in Illinois, 1972–74, Grain Industry Task Force Report No. 6.
(56) Wheeler, Edwin M., Utilization and Conservation of Natural Resources—Natural Gas, Docket Nos. R–467 and R–469, Federal Power Commission, Washington, D.C., January 8, 1973.
(57) White, William C., Fertilizer—Food—Energy Relationships, Proceedings: Division of Fertilizer and Soil Chemistry, American Chemical Society, Chicago, Illinois, August 1973.

# APPENDIXES

## Appendix 1—Estimated Fuel Use in Farming, for Crop and Livestock Production, United States, 1969

Gasoline, diesel and LP fuel (LP gas, butane and propane) and total fuel use for the farm business were estimated for 1969 from a cross-section regression analysis of county data from the 1969 Census of Agriculture. To get total fuel used in farming, Census expenditures for fuel and oil were adjusted to include fuel use by custom operators. It was assumed that 20 cents of each dollar of expenditure for machine hire and custom work was for fuel.

The expenditures for fuel use were expressed as a function of selected irrigated and nonirrigated crops and crop groupings, and of selected livestock or livestock groupings on farms or sold. The analysis was initially based on farm practices for Census Economic Class 1 to 5 farms. This did not include the smallest farms. Fuel expenditures per unit (regression coefficients for the selected crop and livestock groupings) were then adjusted upward because fuel use per acre of crops and per head of livestock was greater on the small farms.

The adjusted unit expenditures were then applied to all acres of crops and numbers of livestock. Refined petroleum fuels—gasoline, diesel, LP gas, butane and propane—for the farm business were estimated to be 88 percent of all fuel and oil used for the farm business. The other 12 percent was for motor oil, grease, piped gas, kerosene, and fuel oil for the farm business—similar to the proportion for Census Economic Class 1 to 5 farms (appendix table 1).

Gallons of gasoline, diesel and LP fuels (LP gas, butane and propane) used per acre of crops or head of livestock were determined by dividing the expenditures by the weighted average price per gallon (25.5 cents). To obtain the weighted fuel price, Census expenditures for gasoline, diesel, and LP fuels on Census Economic Class 1 to 5 farms were divided by U.S. prices for these fuels in 1969. The percentage distribution of these fuels were then multiplied by their prices.

Total expenditures for gasoline, diesel, and LP fuels used in farming in 1969 were estimated by multiplying unit requirements times the number of units of crops and livestock.

Total gasoline, diesel and LP fuel (LP gas, butane and propane) use for farming in 1969 was estimated to be about 7.1 billion gallons. Of this total, about two-thirds of a billion gallons were purchased for machine hire and custom work.

APPENDIX TABLE 1.—FUEL USED IN FARMING, UNITED STATES, 1969

| Item | Crops or live-stock[1] (million units) | Fuel and oil purchased: Per unit: Gasoline, diesel, and LP[2] | Fuel and oil purchased: Per unit: Other[3] | Fuel and oil purchased: Per unit: Total[4] | Fuel and oil purchased: Total[5] (millions) | Gasoline, diesel, and LP[2]: Per unit[6] (gallons) | Gasoline, diesel, and LP[2]: Total gallons[7] (millions) |
|---|---|---|---|---|---|---|---|
| Areas of crops harvested: | | | | | | | |
| Corn, grain | 54.6 | $5.06 | $0.69 | $5.75 | $313 | 19.83 | 1,092 |
| Sorghum, grain | 13.4 | 3.22 | .43 | 3.65 | 49 | 12.61 | 169 |
| Other corn and sorghum | 11.9 | 4.28 | .58 | 4.86 | 58 | 16.78 | 199 |
| Wheat | 47.1 | 2.84 | .39 | 3.23 | 152 | 11.13 | 525 |
| Other grains | 33.6 | 3.22 | .45 | 3.67 | 123 | 12.64 | 424 |
| Soybeans | 41.3 | 5.83 | .79 | 6.62 | 274 | 22.87 | 945 |
| Peanuts | 1.5 | 7.59 | 1.03 | 8.62 | 13 | 29.77 | 43 |
| Cotton | 11.1 | 6.77 | .93 | 7.70 | 85 | 26.57 | 294 |
| Tobacco | .9 | 99.44 | 13.55 | 112.99 | 104 | 389.94 | 358 |
| Alfalfa hay | 26.9 | 3.43 | .47 | 3.90 | 105 | 13.47 | 362 |
| Other hay | 36.3 | .90 | .12 | 1.02 | 37 | 3.51 | 128 |
| Silage, grass | 2.1 | 9.36 | 1.28 | 10.64 | 22 | 36.72 | 76 |
| Selected pasture | 46.5 | .84 | .12 | .96 | 45 | 3.30 | 154 |
| Irish potatoes | 1.4 | 14.94 | 2.03 | 16.97 | 24 | 58.57 | 83 |
| Other vegetables | 3.4 | 9.42 | 1.28 | 10.70 | 36 | 36.93 | 124 |
| Fruit | 3.1 | 13.29 | 1.88 | 15.10 | 46 | 52.11 | 160 |
| Other crops | 7.8 | 11.37 | 1.55 | 12.92 | 101 | 44.59 | 350 |
| All crops and pastures | | | | | 1,587 | | 5,476 |
| Number of livestock on farms: | | | | | | | |
| Milk cows | 12.6 | 9.81 | 1.33 | 11.14 | 140 | 38.46 | 483 |
| Other cows | 34.5 | 2.14 | .29 | 2.43 | 84 | 8.39 | 289 |
| Other cattle | 62.0 | 1.91 | .27 | 2.18 | 133 | 7.52 | 466 |
| Number of livestock sold: | | | | | | | |
| Hogs | 87.7 | .75 | .10 | .86 | 80 | 3.14 | 275 |
| Sheeps and lambs | 15.2 | .52 | .07 | .59 | 9 | 2.13 | 32 |
| Broilers | 2,778.0 | .01 | ([8]) | .01 | 22 | .03 | 84 |
| Chickens | 252.2 | .04 | .01 | .05 | 12 | .17 | 43 |
| Turkeys | 106.2 | .05 | .01 | .05 | 6 | .18 | 19 |
| All livestock | | | | | 486 | | 1,691 |
| Total crops and livestock | | | | | 2,073 | | 7,167 |

[1] Acres of crops harvested and livestock numbers were determined as described in footnote 2 of table 15.

[2] LP includes LP gas, butane, and propane. Estimated 88 percent of total petroleum fuel and oil purchased to raise crops and livestock; the same as the percentage for Economic Class 1 to 5 farms in the 1959 Agricultural Census.

[3] Motor oil, grease, piped gas, kerosene, and fuel oil for the farm business. Estimated 12 percent of total petroleum fuel and oil purchased; see footnote 2.

[4] Estimated by cross-sectional regression analysis of county agricultural census data by expressing total petroleum fuel and oil purchased as a function of the crop and livestock categories.

[5] Total expenditures for fuel and oil purchased per unit times the number of units of crops and livestock.

[6] Expenditures for gasoline, diesel and LP fuels (LP gas, butane and propane) divided by a weighted average price of gasoline, diesel and LP gas (25.5 cents).

[7] Gallons of fuel and oil purchased per unit times the number of units of crops and livestock.

[8] Less than 0.5 cents.

Note: Calculations were made with unrounded data.

## Appendix 2—The Impact Upon Agriculture and Rural Areas of Coal and Oil Shale Development

One of the direct impacts which coal and oil shale development may have is a reduction in agricultural production. This will occur through land disturbed and changes in water use as a result of mining, energy processing, energy transportation and associated activities.

### *Land*

Estimates of agricultural land disturbed by the surface mining of coal for the period 1975 to 1990 range from 484,000 acres to 636,000 acres. Based on a middle estimate of projected coal production, a total of 560,000 acres would be disturbed during the period or 315,000 acres of cropland (table 1). Assuming that mined land is returned to its previous use five years after mining, the largest amount of agricultural land disturbed at any one time would be about 226,000 acres during the 1985 to 1990 period.

In addition to lands disturbed directly by the extraction of coal, associated activity can be expected to disturb agricultural lands. Such activity includes: site requirements of such coal processing activity as thermal electric and gasification plants; transportation rights-of-way for railroads, coal slurry lines, gas lines and electric transmission lines; and land requirements for associated commercial and residential activities. For example, a middle projection for gasification plants yield a land requirement of 4,500 acres for 1980, 16,500 for 1985, and 30,300 acres in 1990. A large proportion of these acres are currently in agricultural use.

Agricultural land displaced by oil shale development is expected to be considerably less than that affected by coal mining. Based on a high estimate of oil shale development, by 1990 24,000 acres of agricultural land would be disturbed for oil shale mining and processing; of this 7,000 acres would be cropland. A middle estimate shows these figures to be 15,000 acres and 4,400 acres respectively (table 2). Unlike coal mining, these lands are not projected to return to their former use.

TABLE 1.—AGRICULTURAL LAND DISTURBANCE FROM SURFACE MINING, 5-YEAR INTERVALS, 1975–90[1]

[In acres]

| Land use | 1975–80 | 1980–85 | 1985–90 | 1975–90, cumulative |
|---|---|---|---|---|
| Cropland harvested | 42,336 | 67,119 | 70,726 | 180,181 |
| Irrigated | 772 | 1,139 | 1,440 | 3,351 |
| Nonirrigated | 41,564 | 65,980 | 69,286 | 176,830 |
| Cropland not harvested | 29,745 | 49,887 | 55,055 | 134,687 |
| Total cropland | 72,081 | 117,006 | 125,781 | 314,868 |
| Forest and woodland | 29,609 | 46,908 | 48,803 | 125,319 |
| Pasture, range, and other land | 28,975 | 43,037 | 47,580 | 119,592 |
| Total agricultural land | 130,665 | 206,951 | 226,164 | 559,780 |

[1] Estimates of total land disturbed were calculated from thickness of coal seams and weight of coal. Estimates of agricultural land disturbed are based on OBERS coefficients.

Source: Estimates of coal production and location from U.S. Bureau of Mines, Division of Fossil Fuels. Coal production estimates of the Federal Power Commission, Office of Economics are 13.5 percent lower; those of the National Petroleum Council, "U.S. Energy Outlook—Coal Availability" (1973) are 13.6 percent higher than the Bureau of Mines.

TABLE 2.—AGRICULTURAL LAND DISTURBANCE DUE TO OIL SHALE DEVELOPMENT: 1980, 1985, AND 1990 [1]
[Cumulative acres]

| Land use | 1980 | 1985 | 1990 |
|---|---|---|---|
| Cropland harvested | 180 | 823 | 2,085 |
| Irrigated | 84 | 389 | 999 |
| Nonirrigated | 96 | 434 | 1,086 |
| Cropland not harvested | 204 | 920 | 2,306 |
| Total cropland | 384 | 1,743 | 4,391 |
| Forest and woodland | 52 | 236 | 591 |
| Pasture, range, and other land | 888 | 4,024 | 10,123 |
| Total agricultural land | 1,324 | 6,003 | 15,105 |

[1] Estimates of agricultural land disturbance are based on OBERS coefficients.

Source: Estimates of oil production and land disturbed from "Profile of Development of an Oil Shale Industry in Colorado," University of Denver Research Institute Working Paper No. 2, February 1973.

*Water*

Water requirements of coal development and oil shale can be high. Because the mining of oil shale and a considerable proportion of the increase of the surface mining of coal is anticipated to occur in low rainfall regions of the West, the transfer of water from present uses to energy development may cause problems. Little water is needed to mine coal, but the transportation and conversion processes can have high water demands. If all of the coal were transported out of the region, little water might be required. If all of the coal were shipped out by rail, only a trace of water would be used. If 10 percent of the coal produced in the Northern Great Plains and the Rocky Mountains in 1990 were slurred, 27,000 acre feet of water would be required annually. On the other hand, the processing of coal may involve considerable quantities of water. The largest single coal associated water requirement in the Northern Plains would occur if the National Petroleum Council's high projection for coal gasification were realized.[1] This could amount to 1,020,000 acre feet annually by 1990. This represents the amount of water which could be used to irrigate 300,000 acres of cropland. Extensive generation of electricity from coal is a more likely occurrence. Based on the North Central Power Study estimates, the water requirement for additional thermal electrical generation in the Northern Plains would require an additional 669,000 acre feet annually by 1990.[2] Water requirements for oil shale development range up to 329,000 feet annually by 1990. Some combination of the above is likely, and not necessarily at the extensive development levels.

Although one study shows that there is a surplus of water in the major river basins associated with coal production [3] local situations will frequently be short of water. To ameliorate this, there are various techniques to increase the effective water supply at specific locations. For example, dry cooling of a thermal electric plant may reduce its water requirements to 7 percent of the above level. Possible additional examples include the use of low quality water to slurry coal and weather modification to increase rainfall. The transfer of water by aqueducts is currently feasible, but may raise serious legal problems

[1] National Petroleum Council, "U.S. Energy Outlook—Coal Availability", Washington, D.C., 1973.
[2] "North Central Power Study", Coordinating Committee, North Central Power Study, 1971.
[3] "Productive Agriculture and A Quality Environment: Food Production, Living, Recreation—The Rural Urban Interface", Published by Committee on Agriculture and the Environment, Agricultural Board, Division of Biology and Agriculture, National Research Council, 1973.

concerning water use. Already, legal issues about water use are being surfaced. The damming of streams to retain more water may have environmental implications such as the effect on sceneries. The drilling of high capacity wells or mining itself may disrupt water tables and other water uses.

*Rural living*

The impacts on rural areas by the surface mining and associated development of coal and oil shale goes beyond the effects on agricultural production. Other aspects of rural economic development are also affected. Potential changes in the quality of rural life stem from possible degradation of environmental quality, including visual aesthetics, water quality, air quality and disturbed lands. This may have direct effects on the recreation industry. Influxes of people into these general sparsely populated areas impact rural governments and services as well as affecting the physical environment. Potential housing shortages have several implications. The competition for labor will affect present farms, ranches, and other businesses as well as the incomes of some present residents. Changes in transportation will affect various users, including competition for rail shipments between grain and coal.

## Appendix 3—Methods Used in Making Fuel Consumption Estimates for Family Living Estimates for 1970

The total amount of fuel used in 1970 for family living was derived in two steps. First, the amount used for heating purposes was derived and then the amount needed for other family household purposes was estimated.

To derive the amount of each fuel needed to heat farm homes, the amount of each fuel type necessary to heat the average farm home was multiplied by the number of farm households in the region heating with that type of fuel. These results were further adjusted by a factor to reflect regional temperature differences. The formula used was as follows:

$H_{ij70} = (h_i)\ (n_{ij70})\ (t_j)$, where:

$H_{ij70}$ = amount of fuel $i$ used by farm households, for space heating, in region $j$, in 1970.

$h_i$ = amount of fuel $i$ needed to heat the average farm home.

$n_{ij}$ = number of farm homes heated with fuel $i$ in region $j$.

$t_j$ = ratio of average number of degree day for region $j$ to the national weighted average degree days, with weighting by number of farms.

To estimate the amount of fuel used for family living purposes, several assumptions were made. It was assumed that all cooking and water heating was done with either electricity, LP gas, or utility gas. The 1970 Census of Housing shows that for rural farms, only 4.4 percent of the water heating and 4.3 percent of the cooking was done with fuels other than these three [6, 7]. It was also assumed that in homes heated with LP or utility gas the same fuel was used for water heating and cooking. The validity of this assumption was also supported by data in the 1970 Census. All farm homes were also assumed to use electricity for additional purposes, such as appliances, air conditioning, and lighting.

Therefore, electricity use for an individual home varied by two factors, the climate of the region—measured by degree days—and the type of home heating fuel. The formula used was as follows:

$N_{ij70} = (n_{ij70})\ (c_i - d_j)\ (n_{ij70} + n\text{-}^{5}{}_{j70}) + e_i\ (n_{j70} - n_{ij70})$.

$N_{ij70}$ = amount of fuel $i$ used by farm households for non-space heating, in region $j$, in 1970.

$c_i$ = amount of fuel $i$ used by the average farm household, other than that for space heating.

$c_i = o$ if $i \neq 1, 4, 5$

1 = utility gas

4 = electricity

5 = LP gas

$d_i$ = amount of electricity used by the average farm household for water heating and cooking.

$d_i = o$ if $i \neq 4$

$e_i = e_i = c_i$ if $i - 4$

$o =$ if $i \neq 4$

The total amount of fuel of each type ($I_{i70}$) used by farm households in a given region is a sum of the space heating and other uses.

$$T_{ij70} = H_{ij70} + N_{ij70}.$$

TABLE A1.—ESTIMATED FUEL USE, BY FUNCTION AND FUEL TYPE FOR AN AVERAGE FARM HOUSEHOLD, 1970

| (i) Fuel | Use of fuel | | |
|---|---|---|---|
| | Space heating ($h_i$) | Water heating and cooking ($c_i$) | Other ($d_i$) |
| 1. Utility Gas (cu. ft.) | 100,000 | 29,000 | |
| 2. Fuel Oil (gallons) | 743 | | |
| 3. Coal (tons) | 4.0 | | |
| 4. Electricity (kwh) | 16,560 | 4,892 | 4,167 |
| 5. LP Gas (barrels) | 25.7 | 7.5 | |

The parameters from which fuel was estimated are shown in table A1. These estimates are drawn from several sources, beginning with estimates of energy consumption by individual households [18, 35, 45, 46]. These estimates were checked for consistency with Bureau of Mines estimates of residential fuel consumption and 1970 Census of Housing figures on households using each fuel type [15, 7].

*Projections for 1980*

Projections of fuel use by farm households in 1980 were made by using the Joint Committee on Atomic Energy projections of residential and commercial energy consumption [35]. JAEC changes for the decades 1960 to 1970 and 1970 to 1980 were adjusted to a common population base. The 1960–70 JAEC changes in the use of each fuel type were compared to changes for farm households over the same period [7]. The ratio of these 1960–70 changes was then multiplied by the 1970–80 JAEC projection to estimate changes in fuel consumption by individual farm households. Then these estimates of farm household consumption were used in the same manner as explained for the 1970 estimates to arrive at estimated fuel needs for heating and other uses.

O